

# THE SEAMANS PRACTICE,

*Contayning*  
A FVNDAMENTALL  
PROBLEME in Navigation,  
experimentally verified:

Namely,

*Touching the Compasse of the Earth and Sea, and the  
quantity of a Degree in our English measures.*

Also an exact method or forme of keeping a Reckoning  
at Sea, in any kinde or manner of sayling.

With certayne Tables and other Rules usefull in Navi-  
gation, As also in the Plotting and Surveying of places.

The . Latitude of the principall places in *England*.

The finding of Currents at Sea; and what allowance  
is to bee given in respect of them.

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By RICHARD NORWOOD, Reader  
of the *Mathematicks*.

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LONDON,

Printed for George Hurlock, and are to be sold at his  
Shop at Saint Magnus Corner, 1637.



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*Imprimatur.*

*Feb. 28. 1636.*

*Guil. Bray.*

By RICHARD NORWOOD, Reader  
of the Mathematics.

LONDON,



TO  
THE RIGHT  
HONORABLE,  
ROBERT  
Earle of VVarwick,  
Barron of Lees, &c.

*Right Honorable,*



Lthough the know-  
ledge and practice  
of the Art of Navi-  
gation, bee of late  
yeares growne to a  
farre greater perfection than it can  
appeare to have had in any former

A 2

age:



## *The Epistle Dedicatorie.*

age : And by that meanes the  
VVorld and all the parts thereof  
have beene further discovered,  
yea sayled round about: the traf-  
fick and entercourse of severall na-  
tions how remote soever facilita-  
ted. Knowledge in divine and  
humane things divulged: And  
(which as I conceive is of most  
importance, seeming as yet to be the  
principall scope of the divine pro-  
vidence in discovering these myste-  
ries) the light of the glorious Gos-  
pel of Christ, beeing the mighty  
power of God unto salvation, is ex-  
tended to those silly captives of Sa-  
than in *America*, by meanes of those  
many plantations we have amongst  
them: which plantations (even  
from their first breathing) have  
recei-

*The Epistle Dedicatorie.*

received no smal furtherance from your noble favour and bounty, as I know by my owne experience in that where sometimes I was, and have understood no lesse by others in the rest.

Yet notwithstanding this notable growth and dayly exercise of the Art of Navigation, it still remaines imperfect in some points. For whereas the practice thereof doth especially consist in the knowledge of Latitudes, Courses, and distances, the way of finding distances at sea, namely by the Log and Line, is rather opinionative and conjecturall than certaine, being grounded upon this supposition, that the compasse of the world in any great circle is 21600 Italian

A 3 miles,



*The Epistle Dedicatorie.*

miles, (as they call them) and that such an Italian mile contains 1000 pases, and every of those pases five English feet : and according to these measures they divide their Log-line, and keepe their account of the ships way at Sea.

Having therefore by an experiment which I made a yeare since, found more nearely the compasse of the Earth, and the quantitie of a Degree on the same in our knowne measures, and applyed it to use in Navigation, in this Treatise following : and further added some other such things as I conceived to be wanting in the practice of that Art: I have presumed to present it to your Lordship, aswell because by  
your

*The Epistle Dedicatorie.*

your knowledge in Navigation,  
and the experience you have had  
in your Honorable enterprises at  
sea, you are well able to judge of it:  
as also being confident that accor-  
ding to your noble disposition you  
will favorably accept thereof,  
though otherwise of it selfe unwor-  
thy. The most High God, ever  
blessed and glorious, multiply unto  
your Honour all his blessings in  
Christ Iesus.

*Your Honours in all*

*due observance,*

RICHARD NORWOOD.





*Errata.*

**I**N the Epistle to the Reader, in the third page, line 21 for some,  
I reade joyne. page 2 line 36 read *Vitruvius*. p 5, sixth r ele. entb  
thrice. p 8 l 23 deducted, r deduced. p 14 l 21 or r 05. p  
16 l 7 changes, r chaines. p 18 l 9 345, r 375. l 20 446 r 466. l 25, 5  
r 3. l 26, 3 r 5. p 19 l 10 1596, r 2596. and 2573 r 2537. l 19 1699, r  
1669. l 23, 2701 r 2801. p 20 l 5, 1179, r 1079. p 21 l 23, 2206, r 2006.  
p 22 l 22, s r s e. p 23 l 1 by r be. p 24 l 29, s r s c. p 33 l last 5065 r  
4065. p 35. l 14, forty r fourth. p 36 l 21 intercession. p 37 l 27 stale, r  
scale. l 33, if r that. p 46 l 28, 930 r 939. p 65 l last 9197 r 29197.  
p 83. 23 216 r 23 226. p 110 96 751 596. 196 756 591. p 130 l 25  
BDN r BD. p 132 l 9 n s w, r w s w. p 136 l 6 part, r port.





## TO THE READER.



He circuit of the Earth and Sea (as the circumference of every Circle) containes 360 Degrees; by which degrees the distances thereon are measured, so that the knowledge of the quantity of such a Degree in our known measures is a fundamentall principle in Cosmographie, and Navigation, as upon which is grounded the reckoning of the Ships way or distance run. For though a Mariner being in his voyage on the vast Ocean have sometimes three things to certify him where hee is, and how to shape his course to his desired Port, namely his Latitude, Course and Distance, and sometimes a fourth, namely some neare conjecture of his Longitude by the Variation or otherwise; yet oftentimes (as in close weather) hee hath nothing but his Course and Distance, otherwhiles, onely his Latitude and Distance is his chiefe guide in sailing with his intended Port. I know it is usuall to allow neere 7. Fathoms or  $41\frac{2}{3}$  feet to a knot, and so many of those knots as runne out in halfe a Minute, so many miles they account the Ships way to be in an houre. And if in halfe a minute shee runne  $41\frac{2}{3}$  feete, then in 60 minutes or an houre shee runnes 5000 feete, and thus they account 5000 English feete, or 1000 Paces to bee a Mile, and 60 of those miles to



## TO THE READER.

be a Degree, such as the whole circumference in any great Circle is 360. But how is this knowne to be true? If it be answered, that it is knowne to be so by Experience, then I would know further by what experiment this was found to be so? Where and by whom made? I presse this so much the rather, because I am perswaded wee have at this day as many excellent Navigators in this Kingdome, and as great Voyages performed as from any other place in the World, and I should bee glad to heare of the experimentall resolution of this Probleme by some of them though it were but in running 8 or tenne Degrees neare the Meridian; for so I doubt not but that which I have here written thereof, would receive further confirmation and better entertainment then happely it will now, being so much different from the Common opinion; And the Arts of Navigation and Cosmography would bee much more perfected in short time. For one Error (as a fruitfull Mother) is oftentimes the cause of more, And so the removing of one the occasion of removing others, especially when they doe mutually support one another; As wee shall here shew how the Error in the Projection and use of the Common Sea-chart is supported by this Error of accounting onely 36000 of our feet to a Degree; and this in like sort upheld by that, so that they will stand or fall together. And surely that had fallen long since being so manifestly convinced; if it had not beene upholden by this. For the confuting of that (I meane the Common Sea-chart) it was sufficient to know that the Earth and Sea make one Spherical body, but in disproving and rectifying this, it is necessary to know moreover what is  
the

## TO THE READER.

the quantity of that Sphericall body: and to that end it was necessary to make a sensible application of our known measures, to a determined part of the whole, that so the quantitie of that determined part being knowne, and the proportion ther: of to the whole, the quantity of the whole might also be discovered. And this I have endeavoured in the experiment following, which if I have not handled so exactly in all points as some would desire: (that requiring more time and charge then I could well bestow) Yet I doubt not but it wil be found that I have come very neare the truth. Some happily will censure me, for being my selfe at the expence to make such an experiment. But I was as frugall in it as I cou'd, adding paines and industry to save expence, I came up in ten or eleven dayes, and had other necessary occasions to lead me from the one place to the other, and d this as a thing falling opportunely in my way. But indeed (as in all other parts of Learning, so in the Mathematicks, especially in their application or middle Mathematicks (as some call them;) it is necessary with speculation to Joyn actual and Experimentall praetises; the former being emptie and uncertaine without these. It is true, that the Mathematicks afford large fields of delightfull speculations, wherein a man might walke farre with much pleasure: But if from so many faire flowers he bring home no honey, or from such large fields no sheaves: I meane if he bring not those speculations to some usefull praetises; neither himselfe nor others are like to receive much fruit by them. But this indeed cannot be effected without more labour and difficulty, yea sometimes it requires Mechanicall and bodily exercises, which some



## TO THE READER.

esteem too meane and unworthy to stoop unto. But for mine owne part, I acknowledge to have had my living and maintainance by the Mathematicks, and not by Speculation onely, but rather by my practise therein; and therefore also I desire (what in me lyes) to make them fruitfull to my selfe and others; And to that end have spent in some principall parts of the Mathematicks neare as much time and means in experimentall practises and conclusions, as in the Speculation. Moreover considering that this particular experiment was proposed above 30. yeares since, by our Country-man Mr. Edw. Wright, to invite some to the tryall of it, as a thing which he would have done himselfe, if he had found such furtherance and opportunity as he desired, which it seemes he did not, nor any other since that time: rather then so noble and so necessary a Problem should longer rest unresolved, I tooke the opportunity offered, hoping it may be an occasion to whet on some others to doe the like. This with some other things which I conceived to be wanting in the Practise of Navigation, I have handled in this ensuing Treatise; Which I commend to your friendly acceptance. Farewell.

In the first, 1636.

THE



# THE SEA-MANS PRACTICE.

## CHAP. I.

*The Common opinion touching the compasse of the  
Earth, and the quantitie of a Degree  
of the same.*



T is a common received opinion in *England* (and the like is in other places) that allowing five of our *English* feet to a *Geometricall* pace, a thousand of those Paces make an *Italian* mile, and sixty of those Miles in any great Circle upon the Spherical surface of the *Earth* or *Sea* make a Degree; and thus it is supposed that a degree contains 60 Miles or 60000 Paces, or 300000 of our *English* feet; and by such miles doe Mariners



in their Voyages by Sea keepe their reckonings. And because the whole circumference of a Circle is 360 Degrees; therefore the compasse of the Earth according to this opinion should be 21600, such *Italian* miles, or 21600000 Paces, or 108000000 of our *English* feet. Whence this opinion came, or upon what experiment it should be grounded, I cannot certainly say; It may seeme to be taken or rather mistaken from *Ptolomey*, who saith, there are 500 *Stadiums* in a Degree, the same was before affirmed by *Marinus Tyrius*, of whom *Ptolomey* speaking in the 11<sup>th</sup> Chapter of his first Booke of Geography hath these words, *Sed in hoc quoque recte sentit partem unam qualium est circulus maximus tricentorum sexaginta, quinginta in terra constituere stadia, id enim confessis dimensionibus consonum existit.* Now a *Stadium* not onely amongst the *Greeks* but as appears by *Herodotus*, amongst all other nations of *Asia*, and in *Egypt* did consist of 600 feete or 100 *Orgyas*, an *Orgya* containing six feete or foure cubits as our fathom doth, the same also is testified by *Suidas* and others; so that a degree containing 500 *Stadiums*, and every *Stadium* 600 feet, it follows that a degree must containe 300000 feet; exactly agreeing in number, with the common received opinion in *England*, which therefore may seeme to bee hence derived, and would also receive much confirmation hereby, (he being an Author of such approved credit) if it could be approved that our *English* feete were exactly equal to the *Egyptian* or *Alexandrian* foote, where *Ptolomey* wrote. Otherwise that being true that so many of their feete make a degree, it will follow that if ours be greater, there be fewer of them contained in a degree; if lesser (as undoubtedly they are) there must be more of them contained in a degree.

*Philander* in his commentary upon the third Chapter of the third booke of *Vitruvius*, hath expressed the quan-

quantity of the ancient *Romane* foote, where (by a competent allowance for the shrinking of the paper being printed wet) it may probably be gathered that it was something longer then our English foote. But the *Alexandrian* and *Egyptian* foot was much greater, for according to *Heromechanicus*, five *Alexandrian* feete were equall to six *Romane* feete: seeing then the auncient *Romane* foote was something greater then ours, the *Alexandrian* foot must needs be much greater then ours. So that wheras *Ptolomey* saith there are 500 *Stadiums* in a degree, and as wee have shewed a *Stadium* did consist of 600 feete, these being *Egyptian* or *Alexandrian* feete as it is most probable, being the place where *Ptolomey* lived; there must bee a farre greater number of our feete in a *Stadium*, and so in a degree, whence it is evident that there is no sufficient footing for this common opinion in the assertion of *Ptolomey*,

Neither doth the practice and experience of Mariners in their Voyages at Sea prove it; for there is no reckoning or experiment at Sea set down by any (that I have seene) to confirme it. And though it be true that in sayling betweene two places that lye neare to one and the same Parallel, they ground their reckoning chiefly upon this supposition, that 300000 of our *English* feet make a Degree, yet can they seldome or never by those reckonings discerne the errour, the rather for that they have bene, and for the most part are still kept upon the Plaine or Common *Sea-chart*, which makes a degree in any parallel equal to a degree in the Equinoctiall; and so makes a Degree in any parallel to containe 300000 feet: And it is true, that in some Parallel a Degree doth containe onely 300000 of our *English* feet, namely about that parallel which is in Latitude 35 degrees as wee shall further shew hereafter) neare unto which have the principall of our Eastern



sterne and Westerne voyages beene made. And thus though this opinion of 300000 feet in a Degree and the projection of the *Common Chart* be both erroneous, yet because the error of the one doth something save the other, they could not be so easily discerned by experience onely.

This opinion of 300000 *English* feet to a Degree may seeme also to be something confirmed by an Observation made by our Countrey man Mr. EDWARD WRIGHT upon Mount *Edgecombe* neere *Plimouth*, of the *Semidiameter* of the Earth which he hath set down in his Booke, *Of the Correction of Errors in Navigation*, Chap. 15. Where hee findes the *Semidiameter* to be 18312621 of our *English* feet, whence it may be gathered, that in a degree of a great Circle of the Earth, there should not bee full out 320000 of our feet; but the way by him then used, though it was very fit for the end whereunto hee there applyes it, namely to finde the dipping or depression of the apparent *Horizon* beneath the true, according to the height of the eye above the water; yet will it easily be granted to be no exact way for finding the *Semidiameter*, and consequently the Circumference of the Earth or the quantity of a degree on the same, and so he sayes there, that hee used that way because he wanted opportunity to put in practice a more exact way. Wherefore for the further satisfaction of my selfe and others in this Point, and chiefly for the necessary use it hath in the practice of *Navigation*, I have made the experiment following, that so the quantity of a Degree, and of the whole Compasse of the Earth might at leastwise be nearely knowne in our *English* measures.

CHAP. II.

An Experiment made for finding the quantitie  
of a Degree, and so the Circumference  
of the Earth and Sea in our  
known measures.



Having occasion to be in the City of  
Yorke, about the beginning of *June*,  
*Anno 1635*. I made there severall  
observations of the *Meridian* Alti-  
tude of the Sunne, the last of which  
was made the eleventh day of *June*;  
the sky was every of those dayes

some thing overcast at Noone, yet not so much but  
that an observation might be made to a neare skant-  
ling: And because the last of those observations is  
most fit for the present occasion, and that day was as  
cleare as any of the other, wee will here especially  
make use of that being, as followeth.

• Upon the ~~fixth~~ <sup>eleventh</sup> of *June 1635*. I made an observati-  
on neere the middle of the Citty of *Yorke*, of the *Me-*  
*ridian* Altitude of the Sunne, by an Arch of a *Sextant*  
of more then five foote *Semidiameter*, and found the  
apparent Altitude of the Sunne that day at noone to be  
59 deg. 33 min.

I had also formerly upon the eleaventh day of *June*,  
*Anno 1633*. observed in the Citty of *London* neere  
the Tower, the apparent *Meridian* Altitude of the  
Sunne, and found the same to be 62 deg. 1 min. <sup>eleaventh</sup>

And seeing the Sunnes declination upon the ~~fixth~~  
day of *June 1635*, and upon the ~~fixth~~ <sup>eleaventh</sup> of *June 1633*  
was one and the same without any sensible difference,  
and because these Altitudes differ but little, wee shall  
not neede to make any alteration or allowance, in re-  
spect

C



spect of Declination, Refraction or Parallax : Wherefore subtracting the lesser apparent Altitude, namely 52 deg. 33 min. from the greater 62 deg. 01 min. there remains 2 deg. 28 min. which is the difference of Latitude of these two Cities, namely of *London* and *Yorke*.

Also by the foresayd observation made in *Yorke*, it appeares that the Latitude of that City is 53 deg. 58 min. almost.

But to our purpose, comming at that time from thence to *London*, I further found by measure, that the parallel of *Yorke* is from the parallel of *London* 9149 chaynes, every chaine being six poles, and every pole 16½ of our English Feet ; that is, every Chaine Ninety nine Feet. (After what manner I found this to be so, we shall further expresse hereafter ; ) But thus as I say, I found that *Yorke* is more Northerly then *London* by 9149 chaines : And before we have noted that these two places differ in Latitude 2 deg. 28 min. therefore it followes that 2. deg. 28. m. of the *Meridian* on the earth and Sea is equall to 9149 chaines. And if accordingly we would know how many of these chaynes are contained in one degree, we may find that by the rule of Proportion first reducing the degrees into minutes, and then say,

If the difference of Latitude	— 148	co. ar.	7, 82974
give such a number of chaines	— 9149		3, 96137
then one Degree, that is	— 60		1, 77815
gives of such chaynes	— 3709		3, 56926

and somewhat more ; namely five feet, which reduced into feet, make 367196, that is 367200 feet in a degree lacking 4 feet, which here we regard not.

Thus then according to this experiment it is evident that one degree of a great Circle measured on the Earth is neare 367200 feet, which in our poles of 16½ feet, is 22254 poles and about one halfe, and these reduced into Furlongs at 40 poles to the Furlong, make

make 556 Furlongs and 14 poles, and lastly these reduced into our English miles, of 8 Furlongs to a mile make 69 miles and 4 furlongs 14 poles, that is 69½ miles and 14 poles in a Degree.

And hence according to the most approved *Hypothesis* of the *Sphericity* of this *Terrestiall Globe*, we may find the compasse of it as followeth. But first, you may note that we speake not here of the compasse of the earth in any parallel or lesser circle described upon any side thereof, (that being various according to the different distance of those circles from their poles) but of the compasse taken in the middle or greatest thicknesse of the Globe, namely in any great Circle, such as divide the whole Globe into two equall parts, of which kinde are the Equinoctiall and all Meridians, &c. this being properly the *Perimeter* or *Compasse* of a *Sphericall Body*.

Now seeing a Degree is the 360 part of the circumference of a Circle (for any circumference being divided actually or by supposition into 360 equall parts, those parts are called degrees) if we can finde how many Feet, paces, miles, or other known measures are contained in one of those degrees, then shall we easily conclude how many of the same known measures are contained in the whole Circumference: But by the former experiment we finde, that in one degree of a great Circle on the *Sphericall Superficies* of the earth there is contained 367200 feet, therefore it is evident that 360 times 367200 feet, is the compasse of the whole; wherefore multiplying 367200 by 360 the product is 132192000 feet, which reduced into poles is 8011636, and these reduced into Furlongs, are 200290 Furlongs 36 poles, and lastly these reduced into miles, are 25036 English miles and somewhat more, for the circuit of the Earth and Sea.

If further we desire the Diameter and Semidiameter of the earth, forasmuch as it is proved by *Archimedes*



medes that the proportion of the circumference of a Circle is to the Diameter thereof, almost as 22 to 7; therefore by the Rule of Proportion, as 22 to 7, so is the circumference of the Earth to the Diameter thereof, so that multiplying the circumference of the earth, namely 132192000 Feet by 7, and dividing the Product, namely 925344000 by 22 the quotient, namely 42061091 is the Diameter of the Earth in Feet, the halfe whereof, namely 21030545 Feet, is the Semidiameter of the same being 21 millions of Feet and somewhat more: these reduced into English miles as before we did the circumference, shew the Diameter of the Earth to be 7966 miles and somewhat more, and the Semidiameter 3983. And thus wee have the Circumference, Diameter, and Semidiameter of the Earth, as also the quantity of a Degree of the same Circumference in knowne measures of Feet, Furlongs and Miles, &c. There are onely two things heere which may seeme doubtfull, namely, the Experiment it selfe, and the *Hypothesis* of the Sphericity of this Terrestiall Globe consisting of the Earth and Sea, for these being admitted, the measures thence deduced as before, will necessarily follow.

Now touching the experiment, I confesse that to have made it so exactly as were requisite and in all points so as I shall shew in the Chapter following, would have required much more time and expence, then mine ability would reach unto; Yet having made observation at *Yorke* as aforesayd, I measured (for the most part) the way from thence to *London*, and where I measured not, I paced; (wherein through custome I usually come very neare the truth) observing all the way as I came, with a circumferentor, all the principall angles of position or windings of the way (with convenient allowance for other lesser Windings, Ascents and Descents). and these I layd not downe by a  
Protractor

Protractor after the usuall manner, but framed a Table much more exact and fit for this purpose, as we shall after shew; so that I may affirme the experiment to be neare the truth.

Touching the *Hypothesis* that the Earth and Sea make one Sphericall or round body, it is generally agreed upon by all the principall Philosophers, Astronomers, Geographers, and Navigators ancient and moderne, some reasons demonstrative for the confirmation thereof may be these.

First, the Eclipses especially of the Moone, which are caused by the shadow of the body of the Earth being interposed betweene the Sunne and the Moone and forasmuch as this shadow doth fall upon the Moone, alwayes and on every side circular, and so appears to us, it is manifest by the Opticks that the Earth from whence it proceeds is a Sphericall body.

2 Likewise the Eclipses of the Sun which are caused by the interposition of the Moone betweene the Sunne and those places where it appears eclipsed; I say it could not bee determined when and in what place such an Eclipse should appeare, and where not, if the forme of the Earth were not knowne; but seeing the places where such eclipses happen, and where not, may be and are usually determined, and that upon this ground; that the Surface of the Earth is Sphericall, it is thence also ratified to be a truth.

3 The Sunne, Moone and Starres, doe rise and set, and are upon the Meridian sooner to those that are resident in the Easterne parts, then to others more Westerly, and that in a proportion answerable to the roundnesse of the Earth, as the Planets and Starres are upon our Meridian at *London* sooner by almost foure houres, then they are to those that inhabit *Summers Ilands*, and the *Confines of Virginia and New-England*.



*England*; And so in *East-India*, and other Easterne Regions, the Sunne and Starres are sooner upon their Meridian then upon ours, which is manifest to be so, as by other reasons, so especially by the Eclipses of the Moone, for an Eclipse of the Moone hath not in it selfe any diversity of time, being at one and the same instant without respect of places, yet because in the Easterne parts, the day is begun and it may be farre spent before it begin in places farre Westerly, therefore such an Eclipse may appeare to the Easterne inhabitants towards the end of their night, which to the Westerne appears in the beginning or middle of the same night with them, and so the difference will be more or lesse, according to the different distance of those places in Longitude.

4 Furthermore we see, that going or sayling to the Northwards, we have the Articke Pole and Northern Starres more elevated and the Antartick Pole and Southerne Starres more depressed, the Elevation Northerly increasing equally, with the depression Southerly, and either of them proportionall to the distances which we goe, the like happeneth in going to the Southwards. Besides the oblique ascensions, descensions, occultations, emerfions, and amplitudes of rising and setting of the Sunne and Stars, in every severall Latitude agreeable to the *Hypothesis* of the Earths Sphericity. All which could not be so, if the Earth were of any other then of a Sphericall forme.

5 So if we stand upon the Sea-shore, and see a Ship farre off under sayle making towards the Land, at first we see onely the top-Sayles or highest parts, and withall doe manifestly behold the convex superficies of the Sea, as it were raised and interposing it self between our sight and the Hull or lower parts of the Ship til she approacheth nearer, and this uniformly, every wayes alike, & proportionably to the severall distances which doth evidently demonstrate the Sphericall roundnesse thereof.

6 Lastly

6 Lastly (to adde no more )the Navigations of these latter times make it apparent, those especially that have beene made round about the world, as those two voyages by our famous Country-men Sir *Francis Drake*, and Master *Thomas Candish*, both which severally sayling from our Coasts to the *West-Indyes*, and passing the Streights of *Magellane* continued their course Westerly till they came into these parts which are from us to the Eastwards, namely to the *East-Indyes*, and so sayled still Westerly till they came to *Cape bon Esperance*, and thence returned into *England*, having sayled about the whole terrestiall-Globe, they found nothing by their observations or reckonings dissonant from the uniforme-Sphericity thereof in all its parts. That they came short in the number of dayes, one, or reckoned the time of their absence lesse by one day and a night then they which remained at home, this further confirms the thing in hand.

Yet whilst we speake here of the roundnesse of the Earth and Sea, we intend it not so strictly as if it were a thing turned round without any inequality in its Superficies; But as a Bowle or Ball, though it have some dust or small graines of sand cleaving thereto may still be said to be round; so though the Land, Hills, and Mountaines be somewhat raised above the Sphericall Superficies of the Sea, and if there should be also some Valleys or bottomes more depressed, yet seeing the greatest of these inequalities have scarce any sensible proportion to the whole, wee may well affirme the whole to be round.

The relations made of the prodigious height of some Mountaines, as to be 60, or 70 miles high, if it be understood of their perpendiculer or direct height are fabulous; The Mount *Atlas* recorded by some of the Ancients to reach up almost to the Moone, and to bee as it were a Pillar for the Heavens to rest upon, being  
measured



measured Geometrically by *Eratosthenes*, the perpendicular or upright height from the toppe thereof to the valleyes beneath, was found not to exceed tenne *Stadiums*, which of our *English* measures is little more then a mile & a quarter, a *Stadium* not much differing from our Furlong, and the like might be shewed of others. But if we admit the highest Mountaines to rise perpendicularly above the Sphaerick-Superficies of the Sea two miles, yet seeing the Diameter or whole thicknesse of the Earth, is as we have before shewed 7966 miles, this exorbitancy or difference of two miles is of small moment; yea if there were any Mountaine eight miles in height upright, yet this compared with the whole thicknesse of the Earth is little more then one thousand part thereof; therefore wee may conclude that this terrestiall-Globe consisting of the Earth and Sea is Sphaerickall. Wee come in the next place to shew by what way of measuring we found the Parallel of *Yorke* to be distant from the Parallel of *London* 9149 chaines. And so how the distance of the Parallels of two places may be exactly measured.

### CHAP. III.

*A most exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a degree on the same.*



Doe the more fully set downe the way of making this experiment, that so I may give occasion to any who are so nobly minded for a publique good, as to be at that charge to make a further and more exact tryall thereof. Now then the best and perfectest way is, to observe so exactly as may bee the

the Summer Solstitiall-Altitudes of the Sunne at two places, so farre distant asunder & lying so neere North and South each from other, with so direct and faire a way betweene them as conveniently may be chosen; Suppose for example *Christ-Church* and *Barwick*, or some other place in the furthest parts of *Scotland*, for the further these two places are each from other, the more perfectly may this businesse be performed: Then measure as truely as is possible and set down in a book, all the way betweene those two places, with all the Windings, Ascents, and Descents that are therein, whereby with helpe of the ensuing Table, you may easily and exactly finde how much the one place is more Southerly then the other. For this purpose the *Plaine Table* is not the fittest instrument, but rather a *Theodelite* or *Peraetor* or some other of that kind, observing diligently the *Variation* of the Needle. The Chayne may be six Poles long, or rather 100 feet, and the Table fitted accordingly, (but the Table following is for Poles) if it should be much longer it would be too hea-  
vie.

The High-ways are commonly crooked, yet because of sundry Obstacles and Impediments which are incident out of the way, and because a man cannot certainly at first direct himselfe the neereft and best way to the place intended, it would be expedient to measure the distance as aforesaid; first in the High-ways leading from the one to the other, and then in the neereft and best way that could be chosen betweene them, and so if any notable errour happen in the one, it may be discovered and amended in the other. The forme which I observed in setting downe the Measures and Angles, was according to this Example.

D

Deg.



Deg.	Distan.	North.	South.	East.	West.
S E. 31					
S E. 20					
S E. 13					
S E. 13					
SW. 02					
S E. 05					

It is to be understood, that the Table here following was before calculated to serve instead of a *Protractor*, for a Circumferentor or other Graduated Instrument, and for a chayne of three Poles, which for the most part I use; yet it may very well be applyed to a chaine of six Poles (as in this businesse it was) reckoning every chayne to be two, &c. And thus for every ten chaines of six Poles, to a chayne I make two stroaks signifying two changes or 20 chaynes, and if there bee any odde chaynes, for those I set a figure in another line next below, and if moreover any odde Poles, whether one or two; for those I set another figure in a third line below. Thus the last entrance before going, being

7005.

S E. or deg. ||||| signifies that the Line upon

5

2

which I went, was from the South-part of the Meridian to the East-wards, making an Angle with the Meridian of 5 deg. the nine stroakes signifie nine changes or 90 chaynes, the figure 5 signifies five chaines, and the figure 2, two Poles. So that it is to be read thus;

South

South Easterly 5 Degrees, 9 Changes, 5 Chaines, and 2 Poles; and the like is to be understood of the rest. But for the most part having liberty of ground, I end the measure of every Line, eyther with a whole number of Changes, or at least of Chaynes.

And thus proceeding all day, towards the Evening or when else I have time convenient, I reduce all these distances upon what Lines or Angles soever they be, to Distances of North or South, East or West, as here appeares;

Deg.	Distance.	North.	South.	East.	West.
S E. 31			3571	1545	
S E. 20			3819	1026	
			1692	616	
			0169	062	
S E. 13			3923	675	
S E. 13			1754	404	
S W. 02			1499		053
S E. 05			2690	235	
			0149	013	
			0020	002	
Chaynes.	571		16286	4578	052
	2			0	52
Poles.	1715		16286	4526	

We will explaine the last, and so the rest may easily be understood: S E 5 deg. ||||| 5. 2, here because I have S E, the numbers taken out of the Table must be put in the Columes entituled South and East. Then in the Table under 5 deg. I looke for 9 Changes



Changes, and finde against it 2690, and in the adjacent Columne under the Complement thereof 235, and because *SE* 5 deg. is lesse then 45 deg. that is nearer to the South then to the East, I put in the Columne entituled *South* 2690, and in that entituled *East* 235; then againe in the same Tabular Columne under 5 deg. I finde against 5 Changes (cutting off a Figure, because 5 Chaines is but the tenth part of 5 Changes) 149 to be put in the South Columne, & 13 for the *East* Columne. Lastly against 2 Poles, I finde for the *South* Columne 20, and for the *East* 2, and the like is to be understood of all the rest.

Now supposing this last to be a place whose distance and situation from the first is required, I sum up the Columns severally, and of the *North* and *South* Columns, subtract the lesser from the greater, and so of the *East* and *West* Columns, and so it will appeare how much *North* or *South*, and how much *East* or *West* the last place is from the first.

As in this example, we finde the last place to be to the Southwards of the first 1628 Poles, for the last figure may be cut off, being used in the Table, onely for the more exactnesse, or may be made a Fraction and so it is  $1628\frac{6}{10}$  Poles; Likewise the last place is to the Eastwards of the first  $452\frac{6}{10}$  Poles, and thus I proceed all the way.

Now touching the Angles of ascent and descent of Hills and Valleyes, to have observed them exactly, would have required more time and charge, then I could of my selfe bestow; yet I made allowance for such of them as were of most moment, he that would observe them all, may eyther make two or three Columns more, or keepe an account of them apart by themselves. But if he intend no further use of them but to finde the nearest distance, he need not set them downe, but make allowance for them on the ground, keeping his distances intire without Fractions. As admit,

mit, I observe the Ascent from a Valley to the brow of a Hil to be 14 deg. above the *level* or *Horizontall Line*, and that measuring, I find the distance to be 30 Poles; I turne to the Table, and under 14 deg. and against 10 Chaines, I find 2911 and 716; shewing that the *Levell* or *Horizontall* distance from my Station to that brow is onely 29 $\frac{11}{100}$  Poles, and that the height of that brow above the *levell Line*, is 7 $\frac{26}{100}$  Poles: But finding thus that the *Hypothenusal* being 30, the *Base* or *levell Line* is but 29 $\frac{11}{100}$ , that is lesse by  $\frac{89}{100}$ , because I would avoyd this Fraction, I adde to the end of the foresayd measure of 30 Poles upon a *levell Line*  $\frac{89}{100}$  of a Pole, and then I may account my selfe distant from the place in the Valley where I made Observation, 30 Poles in a *Level* or *Horizontall line*, and so set downe the Distance without a Fraction, the like is to be understood of all other Ascents and Descents.

Here followeth the Table.

	1. deg	89. d.	2. d.	88. d.	3. d.	87. d.	4. d.	86. d.	5. d.	85. d.
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	598	63	896	79
4	1200	20	1200	42	1198	62	1198	84	1195	105
5	1500	26	1500	53	1497	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	147	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	2993	210	2989	262
1	10	0	10	0	10	0	10	1	10	1
2	20	0	20	1	20	1	20	1	20	2



	6.deg 84.d.		7.deg 83.d.		8.deg 81.d.		9.deg 81.d.		10.d.	80.d.
1	298	31	298	37	297	42	296	47	295	52
2	597	62	596	74	594	84	592	94	590	104
3	895	94	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1489	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2089	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	2984	314	2978	366	2971	418	2963	469	2954	521
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11.d.	79.d.	12.d.	78.d.	13.d.	77.d.	14.d.	76.d.	15.d.	75.d.
1	295	57	293	62	292	67	291	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	882	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	468
7	2060	401	2055	436	2047	472	2038	508	2030	544
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2631	608	2620	653	2610	699
10	2945	572	2934	624	2929	675	2911	726	2898	777
1	10	2	10	2	10	3	10	2	10	3
2	19	4	19	4	19	4	19	4	19	5

0.d.	16.d.	74.d.	17.d.	73.d.	18.d.	72.d.	19.d.	71.d.	20.d.	70.d.	
52	1	888	83	287	88	285	93	284	98	282	103
104	2	576	166	574	177	570	186	568	196	564	206
156	3	865	250	861	264	855	279	851	294	846	308
208	4	1153	332	1148	352	1140	371	1135	391	1128	411
260	5	1442	413	1434	438	1426	463	1418	488	1410	513
312	6	1730	496	1721	526	1711	556	1702	586	1691	616
364	7	2019	580	2008	615	1997	649	1986	684	1973	719
417	8	2307	663	2296	703	2282	743	2270	782	2255	822
469	9	2596	746	2583	791	2567	836	2552	880	2534	924
521	10	2884	827	2869	877	2853	927	2836	977	2819	1026
1	1	10	3	10	3	10	3	10	3	10	3
2	2	20	5	19	6	19	6	19	6	19	6

75.d.	21.d.	69.d.	22.d.	68.d.	23.d.	67.d.	24.d.	66.d.	25.d.	65.d.	
7	1	280	107	278	112	276	117	274	122	271	127
15	2	560	215	556	224	552	234	548	244	544	254
23	3	840	322	834	337	828	351	822	366	816	381
31	4	1120	429	1112	449	1104	468	1096	488	1088	508
38	5	1400	537	1391	562	1380	586	1370	610	1360	634
46	6	1680	645	1669	674	1656	703	1644	732	1632	761
54	7	1960	752	1947	786	1932	820	1918	854	1904	888
62	8	2240	860	2225	899	2209	937	2192	976	2175	1015
69	9	2521	968	2504	1011	2485	1054	2466	1098	2447	1142
77	10	2801	1075	2782	1124	2761	1172	2740	1220	2719	1268
3	1	9	4	9	4	9	4	9	4	9	4
5	2	18	7	18	8	18	8	18	8	18	8



	26.d.	54.d.	27.d.	63.d.	28.d.	62.d.	29.d.	61.d.	30.d.	60.d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	510	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1117	2098	1162	2079	1200
9	2427	1183	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2649	1408	2624	1454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	8	18	10	18	10	18	10	18	10

	31.d.	59.d.	32.d.	58.d.	33.d.	57.d.	34.d.	56.d.	35.d.	55.d.
1	257	154	254	159	252	163	249	168	246	17
2	514	309	508	318	504	326	498	336	492	34
3	77	463	763	477	755	489	747	504	738	51
4	1028	617	1017	636	1007	653	995	671	983	68
5	1285	772	1272	795	1258	817	1243	838	1228	86
6	154	927	1526	954	1510	980	1492	1006	1474	103
7	180	1081	1780	1113	1762	1143	1741	1174	1720	120
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	137
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	154
10	257	1545	2544	1590	2516	1634	2487	1677	2457	172
1	9	5	8	5	8	5	8	6	8	1
2	18	10	16	10	16	10	16	12	16	1

	36.d.	54.d.	37.d.	53.d.	38.d.	51.d.	39.d.	51.d.	40.d.	50.d.	
150	1	343	176	240	180	236	185	233	189	230	193
300	2	486	352	480	360	472	370	466	378	460	386
450	3	729	528	720	541	709	555	699	567	690	578
600	4	971	705	960	721	945	739	932	756	920	771
750	5	1213	881	1198	902	1182	923	1165	944	1149	964
900	6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
050	7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
200	8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
350	9	2185	1586	2157	1624	2126	1663	2098	1700	2069	1735
500	10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
5	1	8	6	8	6	8	6	8	6	8	6
10	2	16	12	16	12	16	12	16	12	16	12

55. d.	41. d.	49. d.	42. d.	48. d.	43. d.	47. d.	44. d.	46. d.	45. d.	45. d.	
17	1	326	197	233	201	319	205	216	208	212	212
34	2	452	394	446	402	438	410	432	416	424	424
51	3	678	591	669	603	658	614	648	625	636	636
68	4	905	788	892	803	878	819	864	833	849	849
86	5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
103	6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
120	7	1584	1378	1560	1406	1535	1433	1511	1458	1485	1485
137	8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
154	9	2036	1772	2006	1807	1974	1842	1943	1874	1910	1910
172	10	2264	1968	2229	2007	2194	2046	2158	2084	2123	2123
	1	8	7	7	7	7	7	7	7	7	7
	2	16	14	14	14	14	14	14	14	14	14



The Structure of this Table is from this ground:

As *Radius* is in proportion, to the distance of 2 places measured in their Rumb, so is the sine of the Complement of that Rumb to the difference in Latitude of these two places.

And so is the sine of that Rumb, to the distance of the Meridians of those two places. As admit I measure South-Easterly 20 deg. 300 Poles, here then the Rumb upon which I measure, making with the Meridian an Angle of 20 degrees, I say,

As *Radius* is in proportion —  
to the distance measured 300 Poles; — 2,47712  
so is sine Compl. the Rumb, S E 20 deg. 9,97299

to the difference of Latitude  $281\frac{9}{10}$ , fere — 2,45011

Whereby it appears that the distance of 5 Parallels of these 2 places is  $281\frac{9}{10}$  Poles; or that the place whereto I measure is more Southerly then y<sup>e</sup> place from which I measured, by  $281\frac{9}{10}$  Poles. Now for the distance of their Meridians, say

As *Radius* is in proportion —  
to the distance measured 300 Poles, — 2,47712  
so is the sine of the Rumb S E 20 deg. — 9,53405  
to their distance in Longitude  $102\frac{606}{1000}$ . — 2,01117

And thus I find the place whereto I measured, is more Easterly then y<sup>e</sup> place frō which I measured by  $102\frac{6}{10}$  Poles & somewhat more. And in like sort may be found all the other numbers expressed in this Table, but having thus found for every deg. to 45 deg. two numbers, y<sup>e</sup> rest may be deduced from them as in this example, 300 Poles at three Poles to the Chayne, is 100 Chaynes or tenne Changes, finding that in ten Changes upon this degree the difference Southerly is  $281\frac{9}{10}$  Poles, it must for five Changes which is just halfe

Ch	Poles.
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

so much by almost 141, and for one change which is a tenth part  $28 \frac{4}{5}$  fere, and so for two Changes twice so much, that is, 56  $\frac{1}{5}$ , for three changes thrice so much, that is the sum of the 2 former, namely 84  $\frac{6}{5}$  & so by Addition onely you may find the rest, as in this Table, which I shall need to prosecute no further. And thus you may make it to the hundreth or thousand parts of a Pole, but this for ordinary occasions, for which it was at first intended may suffice. And according to this example it will be easie to frame the like Table for a Chayne of any other size, or for any other measure which you use.

It may be objected that howsoever this rule holds true in Plaine-Triangles, yet the Triangles heere used are neither Plaine nor Sphericall, for a Plaine-Triangle is made of three right Lines, a Sphericall of three Arches of great Circles, but in this the three sides are of three severall kindes; namely one side is an Arch of the Meridian, and so of a great Circle, another an Arch of a Parallel, and so of a lesser Circle, the third side or *Hypothenusall* being the Rumb, is no Arch of a Circle but a Segment of an *Heli-spherical* Line.

But I answer, that notwithstanding this may be speculatively conceived, & so demonstrated to be no Plaine Triangle, yet in so small distances as these which heere we use, there can be no sensible nor scarce any numerable difference. Yea the distance between 2 Parallels by the Rumb and distance given (being the thing heere chiefly ayimed at) is very exactly found by this rule as before we have shewed, and as is more fully demonstrated by Mr. Wright, in the 12 Chap. of his booke of *the Correction of Errors in Navigation*: whence wee may conclude, that the parts of the Meridian collected by this Table according to the Rumbs and Distances, as we have before shewed, doe give y<sup>e</sup> true measure of the Segment of y<sup>e</sup> Meridian intercepted, between the Parallels of the two places proposed. E 2



## CHAP. IIII.

*Of the difference of Longitude Position and Distance of York and London: And how the Maps of England may by this Experiment be reformed, especially in the latitude of Places.*



WE come next to speake of the Easterly and Westerly distances gathered as before is shewed by these Tables, and to finde thereby the difference of Longitude, and of this we will give an example in the foresaid experiment: whereby we finde that the distance in Longitude, or the East and West distance betweene Yorke and London is neere 14000 Poles, London being so much more Easterly then Yorke. And before we have found that in a degree of the Meridian, and consequently in a degree of the Equinoctiall there, is neere  $3709\frac{1}{5}$  chaines, at six Poles to the chayne, and this 14000 Poles cōverted into such chaines is  $2333\frac{1}{3}$ .

Which  $2333\frac{1}{3}$  chaynes (for finding the difference of Longitude) are not to be reckoned in the Parallel of Yorke, that being too much Northerly, neither in the Parallel of London being too much Southerly; but in a middle Parallel betweene both, namely, about the latitude of 52 deg. 45 min. Now to finde what difference of Longitude is answerable to this  $2333\frac{1}{3}$  chaynes in the Parallel of 52 degrees 45 minutes, say

As Radius is in proportion  $\frac{R}{\sin C} = \frac{\sin C}{\sin P}$  to sine Compl. the latitude  $SE$  52 deg. 45 m. 9,78197 so is  $\frac{1}{2}$  measure of a deg. in  $\frac{1}{2}$  Equinoct. 3709 $\frac{1}{5}$  3,56927 to  $\frac{1}{2}$  measure of a deg. in that Parallel 2245 $\frac{1}{3}$  3,35124.

And thus we find that in the Parallel whose latitude is 52 deg. 45 min. there are 2245 $\frac{1}{3}$  chaynes answering to

to a degree, whereby it appears that the difference of Longitude between *York* and *London* is more then one degree, and to find how much more, say againe by the rule of proportion.

As the measure of a deg.  $2245\frac{1}{10}$ . co: ar: 6, 64876  
is to a degree in Seconds, 3600 ——— 3, 55630  
so is the measure given —  $2333\frac{1}{2}$  ——— 3, 36797  
to the number of Seconds — 3741 ——— 3, 57303

Which reduced, is 1 deg. 2 min. 21 sec. & thus we find that *London* doth differ in Longitude from *York* 1 deg. 2 min. 21 sec. being so much more Easterly.

Thus having the difference of Latitude, as also the difference of Longitude between these 2 places, we may (according to the 2 probleme of sayling by *Mercators Chart*) finde the Rumbe from *London* to *Yorke* to be 14 deg. 20 min. from the North to the Westwards, that is, *N* by *W*. 3 deg. 5 min. Westerly, and the distance in that Rumbe 944 chaines. But their distance in the Highway by reason of the crookednesse and unevennesse of it, was more by about an eight part. And the like might be done for other intermediate places between these, but affecting brevity wee passe that over, as not much pertinent to our present purpose, only expressing the latitudes of some of the principall of them, as followeth.

	Latitude
As the Latitude of <i>York</i> we find to be	53 deg. 58 min.
<i>Doncaster</i> —————	53 deg. 32 min.
<i>Newmarke</i> upon <i>Trent</i> —————	53 deg. 5 min.
<i>Grantham</i> —————	52 deg. 54 min.
<i>Stanford</i> —————	52 deg. 38 min.
<i>Huntington</i> —————	52 deg. 19 min.
<i>Royston</i> —————	52 deg. 3 min.
<i>Ware</i> —————	51 deg. 48 min.
<i>London</i> —————	51 deg. 30 min.

We further noted in this experiment that howsoever the number of miles between *Ware* and *London*, are



almost the same by estimation that they are by measure; yet all the way besides from *Yorke* to *Ware*, a measured mile consisting of 320 Poles is but three quarters of a Mile, as the miles lye by estimation or common account; so that every where (for the most part) three miles by estimation make foure measured miles. And a minute or the sixtieth part of a Degree, is almost in the middle between them both; so that looke how much a measured mile is lesse then a minute, so much or somewhat more is a Mile by estimation greater then a minute; for as there is containd in a Degree, of measured miles 69 $\frac{1}{2}$  and somewhat more, as we have before shewed, so of our common estimated miles, there are contained about 51 $\frac{1}{2}$  in a Degree.

Vpon these grounds the whole Map of this Kingdome might be much rectified, especially in the Latitude of Places, for though we cannot hence determine certainly the Latitudes of any other places besides those which were in the way, or at least in sight as we came up, (the principall of which we have before noted.) Yet we may nearely conjecture the Latitudes of most parts of *England*, by their distances and Positions from these; but these things being besides our scope and purpose in this place, we shall onely compare the Latitude of some principall places probably gathered from this Experiment, with the Latitudes of the same places, as they are set down by Mr. *Speed* in his *Geographicall* Descriptions of *England*: that such as please to examine both in any particulars, may know to which they may more safely leane.

*Canterbury.*

	Lat. by this Exp.		Lat. by M Sp. Map.			Lat. by this Exp.		Lat. by M S. Map.	
	D.	M.	D.	M.		D.	M.	D.	M.
Canterbury.	51	17	51	29	Warwick.	52	20	52	45
Chichester.	50	48	50	51	Northampton.	52	14	52	36
Guilford.	51	12	51	22	Huntington.	52	19	52	44
Winchester.	51	03	51	11	Stamford.	52	38	53	04
Dorchester.	50	40	50	44	Leicester.	52	40	53	06
Excester.	50	43	50	48	Lincoln (Tret.	53	14	53	50
Wells.	51	12	51	22	Newark upon	53	05	53	38
Salisbury.	51	04	51	12	Nottingham.	53	00	53	32
Redding.	51	28	51	42	Darby.	52	58	53	30
London.	51	30	51	45	Stafford.	52	52	53	22
Colchester.	51	58	52	16	Shrewsbury.	52	47	53	16
Ipswich.	52	08	52	30	Chester.	53	16	53	52
Norwich.	52	42	53	10	Lancaster.	54	10	54	57
Cambridge.	52	12	52	32	Yorke.	53	58	54	44
Hertford.	51	49	52	06	Richmond in				
Bedford.	52	08	52	30	Yorkefbire.	54	28	55	18
Buckingham.	52	00	52	20	Kingstone upō	53	48	54	29
Royston.	52	04	52	24	Dōcaster. (Hu	53	32	54	12
Oxford.	51	46	52	02	Durham.	54	50	55	45
Glocester.	51	53	52	12	Carlile.	55	00	55	56
Hereford.	52	07	52	27	Newcastle.	55	03	56	01
Worcester.	52	14	52	36	Barwick.	55	54	57	03

The Latitudes of these places in the first Colume expressed, are such as are probably gathered from this Experiment. But in the second Colume there is set downe the Latitudes of the same places, as they are expressed by Mr. Iohn Speed in his Map of England, set forth in his Booke entituled, *The Theatre of the Empire of Great Britaine*, and least there should bee any mistake in his Mappe, I have conferred these Latitudes thence gathered, with



with the Latitudes of the same places set downe by him in words at large in his descriptions of each severall County, and find them nearely to agree except in the Latitude of *Barwick*, which in his Map he makes to be 57 deg. 03 min. but in his Historicall Description of *Northumberland*, he relates it to be 55 deg. 48 min. which last is much nearer the truth, but seemes not to be his meaning, because then he should make it more Southerly then *Newcastle*. Yea more Southerly then he doth *Carlisle*, which by his Map and also by his words in his Relation of *Cumberland* is in the Latitude of 55 deg. 56 min. Whereas *Barwick* is above 50 Miles more Northerly.

By these you may nearely conjecture the Latitudes of other parts of *England*, lying in or neare the same Parallel with any of them: And hence also it appears that the difference of Latitude between *Barwick*, and the South-coast of *England* neare *Christ-Church*, is little more then five Degrees; not sixe Degrees and more, as some of our Maps make it. But these things we must leave, that we may proceed to that which is principally intended, onely we will first touch a little upon the use of the fore-going Table in Plotting and Surveying of Land.

CHAP. V.

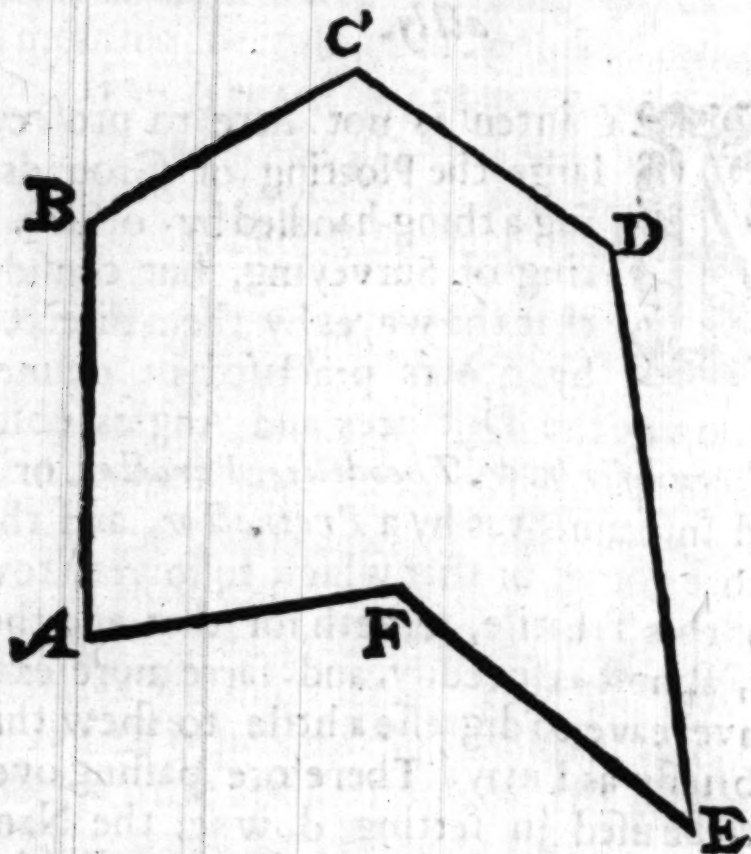
*To Delineate the Plot of any Forrest, Parke,  
Common, or other peeces of Ground, as  
also of Rivers, Harbours, &c.  
Speedily and most Ex-  
actly.*

**M**Y intent is not here to prosecute at large the Plotting of Grounds, being a thing handled by others, treating of Surveying, but considering that the wayes by them directed and by others practised in delineating or laying downe the Distances and Angles observed by the *Circumferentor*, *Theodelite*, *PeraCTOR*, or other graduated Instrument is by a *Protractor*, and that the Table before going, or that which followeth towards the end of this Treatise, serveth for that and the like purposes, almost as speedily, and farre more exactly: I shall crave leave to digresse a little to shew this use of it, as briefly as I may. Therefore passing over the Method to be used in setting downe, the Names of the Grounds, the Tennants, Borderers, and other remarkable things, and leaving every man in these to the wayes whereunto he is accustomed. You may (as sometimes I doe) make a Booke in a long *Octavo*, and upon the left side thereof set downe such things as these before mentioned, reserving every right side, and dividing them by Ruled lines into fixe Columns as here beneath appeareth.

And having taken and set downe your notes in the Field on the left sides or Pages of your Booke, you may in the Evening or next Morning before you goe out, or when else your occasions will permit, set down



in the first Columns on the right side, how many Degrees the Lines upon which you have traversed are distant from the North or South part of the Meridian towards the East or West, and in the second Columns, the quantity of the same Lines, in Changes, Chaynes, and single Poles, and parts of Poles.



As in this Figure, suppose the Line from *A* to *B*, to be directly East, seven Changes, that is seven times 30 Poles, or 210 Poles; from *B* to *C* to the Eastwards of the South 35 deg. 8 Changes and one Chayne, from *C* to *D*, to the Westwards of the South 32 deg. five Changes and four Chaynes, from *D* to *E* to the Westwards of the South 80 deg. ten Changes; from *E* to *F*, to the Eastwards of the North 35 deg. six Changes, three Chaynes, and two thirds of a Pole. And lastly from *F* to *A*, the place where I first began, to the

the Westwards of the North, 9 deg. five Changes, 3 Chaynes 2½ Poles; All these I expresse in the first and second Columes on the right side as here beneath appeareth.

Which done I take the Table, and find there the Northing and Southing, Easting or Westing answerable to these Degrees and Distances, and set them down accordingly. As for the first being East, 7 Changes, I set downe in the East Colume 210 Poles with a Cipher behinde it. For the second being S E, 35 deg. I finde in the Table for 5 Changes, 1228 to be set in the South Colume, and 860 for the East Colume; also upon the same Degree for 1 Chayne 25, for the South Colume, and 17 for the East Colume: and so I proceed with all the rest, till I have finished.

Deg.	Dist.	North.	South.	East.	West.
East.	0			2100	
S E. 35	1		1228	0860	
			0035	0017	
SW. 32	0		1272		0798
			0102		0064
SW. 80	0		0521		3954
NE. 35	3	1474		1032	
		0074		0052	
	0 2	0005		0094	
	3				0234
NW. 09	3	1481			0014
		0089			0004
	2 1	0025			
	2				
		3148	3148	4065	4065

Is a

And

4065.



And being thus returned to my first Station, I sum up severally these foure columes, of North, South, East, and West; and finding that the summe of the North columne is equall to that of the South, and the summe of the East is equall to that of the West. I conclude the whole worke to be truely performed, whereas if there had beene any difference, it had shewed an errour, and if that difference had beene great, it had beene necessary to examine the worke againe, and so to correct it.

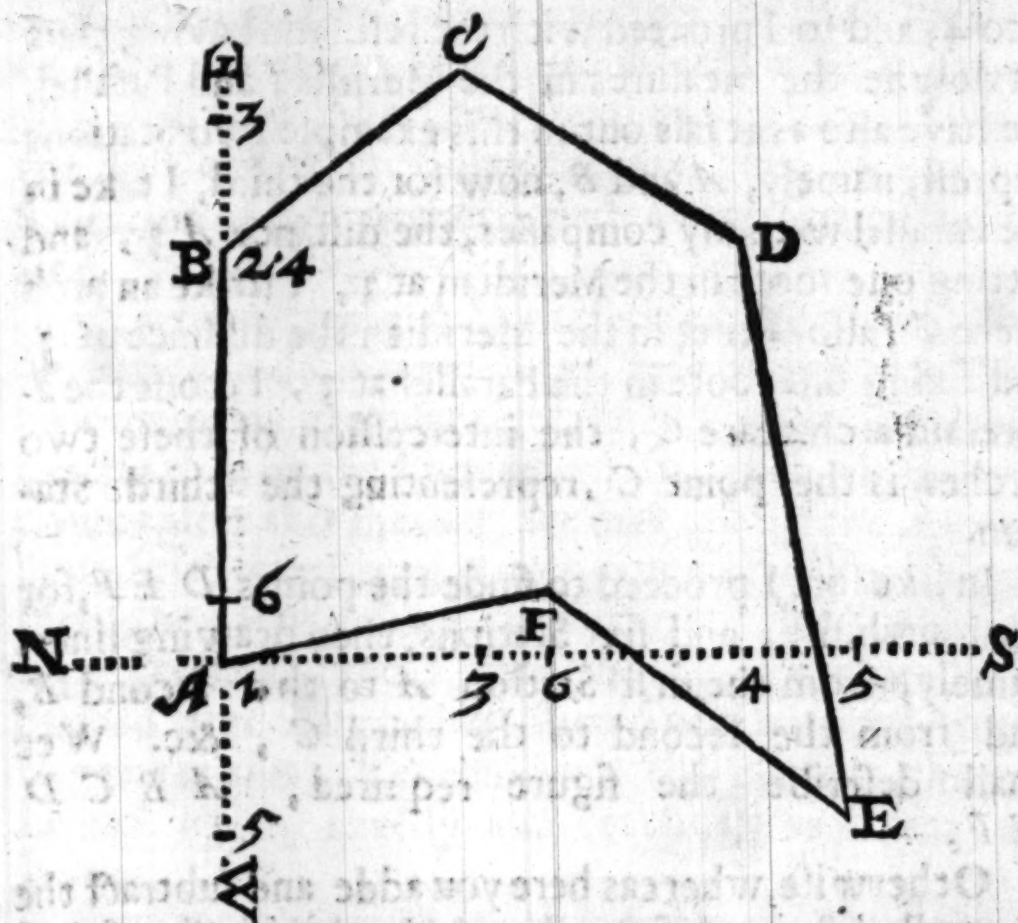
It is usuall to adde together all the Angles, and also to multiply 2 right Angles, or 180 deg. by the number of Angles lacking two, and if the summe of the Angles added together be equall to this product, the worke is thought to be true, as heere if we adde, the inclinations and reclynations of these lines in this figure, the summe is 720 deg. or 8 right Angles, and if we multiply 2 right Angles by 4 (because heere are 6 Angles) the product is also 8 right Angles. But the other by the summes of the columes is a most absolute way for examining the truth of your worke, and to be preferred before any other that I know

It may seeme very laborious to set downe every Station in this manner, but one that is a little exercised in it may as I take it (for I never observed the time exactly) set downe forty or fifty Stations in this manner, within the space of an houre or thereabouts; but I should advise that it be done by two men having each a Table for that purpose to avoyd all mistakings.

If your Instrument give not the Angle with the Meridian expressely. Yet it may easily be gathered thence; or else you may devide a circle as your Instrument is devided, and number the degrees as they are there numbered, which done, number them also from the North and South part of the Meridian towards the East and West, so shall you easily know the Angle of any degree with the Meridian.

Now

Now to proceed, these measures may be set downe in a plot severall wayes. As first, considering which way the ground lyes, I take a point for my first Station, so as the whole may fall conveniently within the plot, which let be the point *A*, by which point I draw a Meridian and Parallel, namely two right lines intersecting one another at right Angles; whereof let *NS* be the Meridian running North and South, and *EW* the Parallel running East and West, this done, I look to the North and South columes, and there first in the South columne, and against the third Station, I finde 1293 that is 125<sup>3</sup>. Poles, this I set in the Meridian from *A*



to the Southwards, and mark the point with the figure 3, then in the South columne against the ~~forty~~ Station, *fourth* I finde 1374 which I set in the Meridian from 3 to 4; also against the first Station, I finde 521 which I set in the Meridian from 4 to 5. Then against the first Station I finde in the North-columne 1553 which I set in the Meridian



Meridian from 5 to 6, also against the seventh Station which is the same; with the first I finde 1595 which I set in the Meridian from 6 and it falls upon *A* which is the first Station, and thus have I done with the South and North columes.

In like sort I expresse the measures in the East and West columes in the parallel *E W*. As finding first in the East colum 2100, I set it downe from *A* to the Eastwards, and it extends to *B*, where I set 2, signifying my second Station, I finde next in the East colum 877 which I set in that Parallel from 2 to 3; next in the West colum 859 which I set in that Parallel from 3 to 4, and so I proceed with the rest. And having thus set downe the measures in the Meridian and Parallel, we have also as it falls out in this example two Stations exprest, namely, *A* and *B*, now for the third, I take in the Parallel with my compasses, the distance *A 3*, and setting one foote in the Meridian at 3, I strike an arch neere *C*; also taking in the Meridian the distance *A 3*, and fixing one foote in the Parallel at 3, I crosse the aforesaid arch neere *C*, the intercession of these two Arches is the point *C*, representing the third Station.

In like sort I proceed to finde the points *D E F*, for the fourth, fift, and sixt Stations, then drawing lines, namely, from the first Station *A* to the second *B*, and from the second to the third *C*, &c. Wee shall describe the figure required, *A B C D E F*.

Otherwise, whereas here you adde and subtract the severall distances of South and North, as also of East & West by your compasses; you may with a little more paines, adde and subtract them by the pen, which is the better way.

As having set downe in the Meridian the Southerly distance

distance of the third Station 1253, I adde thereto 1374 which is against the fourth Station, the sum is 2627; the Southerly distance of the fourth Station, which I set in the Meridian from *A* to 4. Again to this I adde 521, so have I 3148, the Southerly distance of the fift Station *A* 5, from which subtracting 1553, the Northerly Distance set against the sixt Station there remaines 1595, which is the Southerly distance of the sixt Station to be set in the Meridian from *A* to 6. Lastly, from this abating, the Northerly Distance of the first Station from the sixt, which I finde there also to be 1595, there remaines 0. Shewing that I am returned to the same Parallel or East and West Line in which at first I began. And in like sort, you may proceed with the East and West Columns, and then by the intersection of two Arches, finde every Station as before.

Other wayes might be prescribed which will not be hard to finde of your selfe. And as we may thus lay downe any irregular right lined Figure farre more exactly then by the *Protractor*; so when it is layd downe after this manner, we may cast up the *Area* or Superficiall quantity of it very exquisitely; Yea if there should be a Plot drawne (according to the Angles and distances here given) after the usuall manner by a Scale so large that the Plot should be a hundred times so great as this; Yet could not the content thereof be cast up so exactly and certainly as it may be here.

But I must not insift upon these things, they may of themselves be conceived, and mine intent is onely to touch them, <sup>that</sup> if I be not prevented of time, and by other occasions from handling those things which I have here more specially intended. But as I have sayd, this



this course is chiefly to be used in plotting large Grounds, and there indeed are graduated Instruments especially to be used : For other smaller Grounds there is none more fit then the *Plaine-Table*.

# CHAP. VI.

*Of the Compasse of the Earth, and the quantity of a Degree, according to the most approved Experiments, Ancient and Moderne.*



Although the compasse of the Earth hath been in some sort observed by divers of the *Ancients* : Yet for some of them we cannot certainly gather what measures they used ; others used no measure at all, but assumed the distance of places to be such as it was estimated by Travailers to be, and likewise the Latitude ; therefore it will be needlesse to insist upon the examination of their Observations ; others of them which were taken by measure, and which we may upon any good Ground reduce to our Measures, are these which follow.

*Willebrordus Snellius* in his Booke entituled *Era-  
stosthenes Batavius*, cites *Abel Fedas*, a most diligent *A-  
rabian Geographer* that lived about the yeare of *Christ*  
1322 who records, that about the yeare of *Christ*  
827, certain men skilfull of the *Mathematicks*, did  
by the commandement of their Prince *Almanon*, mea-  
sure in the Fields of *Mesopotamia* (as he gathers) un-  
der one and the same *Meridian*, from the North to-  
wards the South, the quantity of a Degree, and found  
it to be 56 Miles or somewhat more. The quantity  
of

of their mile according to *Alphragannus*, was 4000 cubits, or 6000 feet: whence the quantity of a degree should be 336000 feet, but of the length of their feet we are something uncertaine, onely they define it to be so long as the extent of 96 Barley-cornes laid side by side, whereas the *Rhynland*-foote according to tryall by him made, is but the extent of 90 cornes laid in like manner, so that if there be no inequality in the graines, then 90 *Arabian*-feet are equall to 96 *Rhynland*-feet. But 96 *Rhynland*-feet are found to bee about  $91\frac{1}{2}$  *English*-feet, therefore also by the rule of Proportion, 336000 *Arabian*-feet doe make of our *English*-feet 370222. So that according to this experiment of the *Arabians*, a degree should containe 370222 of our *English*-feet. And before wee have found by the observations taken at *London* and *Yorke*, and by the distance of their Parallels measured, that a degree containes of our *English*-feet 367200. The difference is onely 3022 feet that is about the  $\frac{1}{11}$  part of a degree or halfe a minute.

He cites next *Alhazen* the *Arabian*, who in his book *de Crepusculis*, declares the compasse of the Earth to be 34000000 paces; so that proportionally there must be in one degree 66666 $\frac{2}{3}$  paces, that is, 333333 *Arabian* feet. And seeing that 90 *Arabian*-feet make of our *English*-feet 99 $\frac{1}{2}$ , therefore by the rule of proportion 333333 *Arabian*-feet, make of our *English*-feet 367283. So that according to *Alhazen*, there should be in a degree 367283 of our *English*-feet, differing from the experiment which I made, only 83 feet in a degree.

I have not strained these numbers to bring them to this neeren sse, they are the same in effect, which are set downe by *Snellius* in his *Eratosthenes Batavus*, who with great industry and judgement hath compared the measures of the Ancients, and the measures used by severall Nations in these times with the *Rhyn-*



*land-foot.* Much lesse have I strained mine owne numbers to draw them up to these; But on the contrary I confesse upon the sight of his booke, observing the great paines and industrie which hee professeth him selfe to have bestowed, and which I doubt not but he did employ in making his Experiment, and how he had found the measure of a degree to be much lesse then mine as we shall after shew; I began to doubt, that I had not made sufficient allowance for the unevennesse of the wayes, and for some smal bendings, sometimes to the right hand, sometimes to the left, the observation whereof, I wittingly neglected to spare time and expence. For I did often observe a mile or two before me, some mark in the High-way noting the degree and measuring to it in the way, neglecting to observe the intermediate swarvings of the way, sometimes three or foure degrees towards the right hand, sometimes as much to the left, but making such allowance for that, and for the unevennesse as I judged sufficient. And some men may thinke that the exact observation of these lesser things thus neglected and regulated onely by judgement or conjecture might deceive me much: But they may consider, that if there be two places a mile distant, that is in a right line 320 Poles, if you measure from one of these places towards the other, not in that right line, but alwayes swarving from it by an Angle of foure Degrees sometimes to the right hand, sometimes to the left till you come to that other place; I say, that notwithstanding all these swarvings ( if there bee nothing else to augment the measure ) it will not amount to 321. Now considering that I had all the way as occasion required, made such allowance as seemed convenient and so found 367200 feet in a Degree, before I compared it with the measures

asures taken by any other : I resolved not to diminish nor to augment the number thus arising by my observations , measures , and allowances, in respect of the opinions , observations , or measures of any other man , untill there be made some Experiment more evident and exact then any yet extant.

And I am something the more confirmed by the neere agreement of these two testimonies before recited, both exceeding me a little in the measure of a Degree. But we cannot confidently rest upon them, because of that inequality which may be of Cornes or Graines, for theirs may happely be something greater or lesser then ours.

Both these measures of a Degree doe much exceed the quantity of a Degree found by *Snellius*, but when he compares them with his owne another way, namely placing the Barley-cornes so that they may not lye flat but be set up edge-wise, and so by 96 Cornes to make a Foot, and by such feet to measure a Degree ; then he findes that the quantity of a Degree according to the *Arabians* is much lesse then by his Experiment it should be : but if some be layd flat, and others set up edgewise, the *Arabian* measure of a Degree will agree with his. And so he proposeth this doubt, whether the 96 Graines whereof the *Arabian* Foot doth consist, must lye flat or be set up edgewise, or some of them to lye flat, and others to be set up edgewise. But it is most probable that they must lye flat, that beeing the Position which they are apt unto by nature, they cannot be set edgewise without much trouble, especially so many together as make the length of a Foot, and so the *Arabian* measure of a Degree doth nearly agree to this of mine.

We come next to heare the determination of *Prolo-*  
*mey* of *Alexandria*, whose Authority and Credit in



the Solution of this question is not inferiour to any of the Ancients. He affirms the Compasse of the Earth to be 180000 Stadiums, and the quantity of a Degree 500 Stadiums, the same (as *Strabo* saith in his Second Booke of Geography) was before affirmed by *Posidonius*. Also *Marinus Tyrius* (before *Ptolomey*) had determined the quantity of a Degree to be 500 Stadiums. *Ptolomey* confirms it, not simply from their Relations, but as it seems from his owne Experience, and that by some measures diligently taken, for in the XI<sup>th</sup> Chapter of the first Booke of his Geography he hath these words; *Sed in hoc quoque recte sentit, partem unam qualium est circulus maximus tricentorum sexaginta; quingenta in terra constituere stadia, id enim confessis dimensionibus consonum existit.* Also *Lib. 7. Cap. 5.* *Ita ut pars una, seu gradus unus quingenta contineat Stadia, quemadmodum ex diligentibus deprehensum est dimensionibus.* Now a Stadium not onely amongst the *Greeks*, but as appeares by *Herodotus* amongst all other Nations of *Asia* and in *Egypt*, did consist of 600 Feet; therefore a Degree according to *Ptolomey*, must containe 300000 Feet: But the *Egyptian* or *Alexandrian* Foot was much greater then our Foot, for as we have before layd, the ancient *Roman* Foot greater then ours, and the *Egyptian* Foot was much greater then the *Roman*: For it is often testified by *Hero Mechanicus* that five *Alexandrian* Feet, make sixe *Roman* Feet. And *Mr. Snellius* hath very ingeniously gathered both from *Phylander* and otherwise, that the *Rhynland* Foot is equall to the ancient *Roman* Foot, therefore also five *Alexandrian* Feet are equall to sixe *Rhynland* Feet: So that by the Rule of Proportion 300000 *Alexandrian* Feet will make of *Rhynland* Feet 360000. But by the size of our *English* Foot which was sent him from the Iron Standard in *Guild-hall*, he findes it to contayne but

968 such parts as the *Rhynland* contains 1000: So that 968 *Rhynland* Feet are equal to 1000 *English*, or 121 *Rhynland* Feet are equal to 125 *English* Feet. Therefore also by the Rule of Proportion, 360000 *Rhynland* Feet are equal to 371900 of our *English* Feet. Therefore according to *Ptolomy*, there are contained in a Degree 371900 of our *English* Feet. But by our fore-mentioned Experiment made betwene *Yorke* and *London* we finde onely 367200 Feet in a Degree, being lesse then *Ptolomies* by 4700 Feet, that is by  $\frac{1}{8}$  part of a Degree, or  $\frac{1}{4}$  of a minute and little more.

*Fernelius* a moderne Authour and learned Phisitian, measuring the way by the Revolutions of a Wheele, and the Latitudes by Observation, findes in a Degree 68 *Italian* miles, and 96 Paces, the Pace which he used being more then five of our *English* Feet: But because he handled not the Problem exactly and is suspected by *Snellius* (though I thinke without cause) to have grounded his Conclusion rather upon the Experiment of the *Arabians* before set downe (where-with it doth nearely agree) then upon his owne, we will insist no longer upon it.

We come in the last place to the Experiment of *Willebrordus Snellius* a *Hollander*, made in the *Netherlands* about 20 yeares past. We shall not need to recite the particulars of it, being extant at large in his Booke before mentioned, but in Conclusion he findes in a Degree 342000 *Rhynland* Feet. Now a *Rhynland* Foot (as he hath there shewed comparing both together) is greater then ours, and that in such Proportion, as 1000 is to 968, (and so much or little more it appears to bee by that Modell of the *Rhynland* Foot printed in his Booke) therefore 968 *Rhynland* Feet must make 1000 of ours; and hence by the Rule of Proportion, 342000



*Rhynland* Feet will make of our *English* Feet 353306. So that there should be in a Degree onely 353306 Feet which is lesse then we have before found in a Degree by 13894 Feet, that is by  $\frac{1}{10}$  parts of a Degree or  $2\frac{1}{4}$  minutes and something more. He was a man doubtlesse of singular industry and knowledge, and of much exercise in the *Mathematicks*, and it may be, was well experienc'd in this particular, touching the Geometricall mensuration of Distances, and he hath bestowed much paines and diligence in this Experiment, as by his Booke appeareth. But if he had by a Chaine measured the Distance of his two utmost Stations (if the ground would permit, which I suppose it would not) or at least-wise if his measured Stations had been farther distant: I conceive he would have found a greater Distance in his two utmost places of Observation. But if a man intending to finde the Distance of two places, measure onely the  $\frac{1}{100}$  part of that Distance, and by that measured Line, and the Angles think to finde their true distance; Whether he doe it immediately from those two measured Stations, or mediately by helpe of others observed from them, he may easily fall into some notable errour. For though the Probleme bee exactly true in Geometricall Demonstration, how small soever the measure be. Yet it is not so in sensible and experimentall practices by reason of the weaknesse even of the best eye, and the imperfection of the instruments in themselves, and in their use. And besides that, there were many Stations obliquely scituate; A man cannot alwayes hit the just middle of that Turret-Steeple, or other marke which he observes; Neyther when he comes to make his Station there, can he alwayes place his Instrument just at the concurrence of his former visuall Lines, by reason of other impediments. Besides the Force of the Winde in such eminent places: adde moreover that

that amongst so many Steeples as there are in some Townes there, a man may at sometime mistake one for another. And if there should happen no notable Error, by reason of any or of all these Casualties: Yet may two minutes in the difference of the Latitude of two places be easily mistaken, especially being derived from the Latitudes of those places which are very rarely set downe, true to a minute.

If it be objected, that I might as well be so much mistaken in the difference of the Latitudes of *Yorke* and *London*.

I answer, it is not so likely, because I had the opportunity of observing the Summer Solstitiall Altitude of the Sunne in both places, wherein I had no necessary use of the Sunnes Parallax, nor Refraction, nor of the Table of the Sunnes Declination, any of which may cause more then a minutes error, in finding the Latitude of eyther place.

Besides, if mine Error in those Observations should be full asmuch, yet would it not in the Conclusion bee halfe so much, because the Difference in Latitude of the two places of mine Observation, is more then twice so much as that of his.

But let this suffice, leaving every man to embrace that which he shall best approve. Both our Experiments doe sufficiently convince, that common error of accounting onely 300000 *English* Feet to a Degree, besides the consent of other Observations before recited ancient and moderne.

Mr. *Snellius* hath further in that Booke of his entituled *Eratoſthenes Batavum*, with much diligence compared some ancient Measures, as also the



# 46      *The Sea-mans Practice.*

The measures of sundry Forraigne-Countrys with the *Rhynland-foot*; and amongst the rest our *English-foot*, according to a size thereof to him sent from the *Standard* in *Guild-Hall* (from whence also I had about 20 yeares past the size of that foot which I have used in this measure) we shall not need to repeat them all because his booke is extant; some of them are these following, which we heere compared to our *English-foot*, as he hath there done to the *Rhynland*, that so any of them may the more easily be reduced into our feet. Therefore dividing the *English-foot* into 1000 equall parts, we shew how many of those parts are contained in other ancient and forraigne feet.

## Ancient feet compared with our *English-foot*.

Of such parts as the <i>English-foot</i> containes	1000
The Auncient <i>Roman-foot</i> contained	1033
The Auncient <i>Greek-foot</i> containes	1076
The <i>Babilonian</i> cont.	1211
The <i>Alexandrian</i> cont.	1240
The <i>Antiochean</i> cont.	1405
The <i>Arabian</i> cont.	1102

## Forraigne feet compared with our *English*.

Of such parts as the <i>English-foot</i> containes	1000
The <i>Rhyn-land-foot</i> containes	1033
The <i>Dort-foot</i> cont.	1085
The <i>Middleburge-foot</i> cont	992
The <i>Amsterdam-foot</i> cont.	934
The <i>Antwerpe-foot</i> cont.	939
The <i>Lovayne Foot</i> containes,	939
The <i>Hafnian Foot</i> in <i>Denmarke</i> ,	965
The <i>Paris Foot</i> called the <i>Kings Foot</i> ,	1090
The <i>Venice Foot</i> ,	1157
The <i>Toledo Foot</i> ,	896
The <i>Nuriburg Foot</i> ,	1006
The <i>Strasburg Foot</i> ,	920

CHAP.

CHAP. VII.

Of Dividing the Log-line, and reckoning the Ships way.



Here be foure things upon which the Practice of Navigation is especially grounded; namely the knowledge of the Longitude, Latitude, Course, and Distance. Touching the Longitude, though it may be found by the other three, yet hi-

therto there hath not beene delivered any generall Rule true and practiceable whereby the Longitudes of Places might be immediatly & ordinarily found of themselves. The Latitudes of places may immediately be found by observation of the Sunne and Starres, as we have formerly shewed in the Appendix to the Doctrine of Triangles; The Course by the Compasse, the Variation being duely observed, wherein we have many good Mariners very expert, this we have also handled in the Doctrine of Sphericall Triangles. The Distance runne, is found of it selfe by the *Log-line*, whereof we are here to speake.

The ground of finding the Distance runne by the *Log-line*, is meerely conjecturall, being founded upon this opinion, that five of our Feet make a Pace, and a thousand such Paces make a Mile, and that 60 such Miles make a Degree: so that a Degree should containe 300000 of our Feet. But it appeares not onely by this Experiment, but even by all others that were diligently taken and their measures to us knowne, that there is a greater number of our Feet contained in a Degree.

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There



There be three things (as I conceive) that have caused this Errour to be so commonly received and tolerated. The one, for that it doth somewhat counterpoise another contrary error in the practise of *Navigation*, namely in the use of the *Plaine-Chart*, for the error which is there committed, by making every Parallel equall to the Equinoctiall, and so every degree in them greater then they should be; is something moderated by this error, whereby the measure of a degree is esteemed lesse then indeed it is.

For instance; It is evident by the *Globe*, that the Meridians concurring in the Poles, grow nearer and nearer together as they grow towards the Poles: in so much as if two Meridians be distant in the Equinoctiall tenne degrees, that is 600 miles, the same Meridians in the Latitude of 35 degrees will be distant little more then 490 miles. Now if unto every mile we account according to the former experiment 6120 Feet, then is the distance of those two Meridians in that Parallel neare 3000000 Feet. In like sort in the *Plaine Chart*, tenne degrees of that parallel (as of all others) is made equall to tenne degrees of the Equinoctiall or Meridian; so that the distance of these two Meridians will upon the *Plaine-Chart* be 600 miles, but one of these miles containes onely 5000 Feet, so that the distance is but 3000000 Feet, equall to the former.

And although these errors in other cases doe not justly ballance one another as in this example, yet that of the *Plaine-Chart* is alwayes something moderated by this other, and so much the more by how much they are nearer to the foresaid Latitude. I grant that this is onely so, when the course is neare vnto the East or West points; but withall, I say that this kind of reckoning is (in a manner) then onely used: For, he that runnes any course neare the Meridian Southerly or Norther-

Northerly hath a more certaine way of reckoning; namely his Latitude which hee findes dayly by observation of the Sunne and Starres; upon which he will depend, either neglecting or at least not regarding his dead reckoning, Yea (it may bee) never casting the *Logge* so much as once in such a voyage, having a more sure ground for his reckoning. But in a Course that is neare East and West (forasmuch as there is no way discovered for finding the Longitude) hee is driven of necessity to make use of his dead reckoning.

We might adde moreover, that the principall Voyages of this kind, I meane of those which consist of Courses much Easterly and Westerly, as to and from the *West-Indyes*, and the parallel of *Cape bon Espérance* are neere unto this Latitude of 35 degrees; so that as some of them are more Southerly, others of them are more Northerly.

But to insist no longer upon this, I suppose a second cause to bee, for that men commonly desire to haue their reckoning before their Ship (as they say) that they fall not with a place before they looke for it; And this comes so to passe whilest the miles are accounted lesse in measure, and so more in number then they are indeed.

And thus, though there may seeme to be some commodity in these errours, especially when they doe nearely ballance one another; Yet because they seldome doe so, but alwayes leave men in uncertainties, and oftentimes in great perplexity and danger, it is much safer and better to reject them both, and to embrace those wayes which are evidently grounded vpon truth, though there may be in them some more difficulty at the first. Yet I confesse, that he which reformes one and not another, may sometimes erre so much the more thereby. And I doubt not, but



many would reforme them both if they could certainly doe so.

Therefore a third cause of admitting and retaining this Error seems to be, for that there hath beene no way delivered from evident and certaine grounds, for the rectifying of it. I doubt not but many have found Errours in their reckonings arising from hence, that they account onely 300000 of our Feet to a Degree; but not knowing certainly where to lay the fault, have imputed it sometimes to ill Steerage, otherwhiles to the Variation of the Needle, or to some mistake in their Reckonings, or to some error in their Plots, or to some Current or such other Accident, and so the Error hath rested unreformed. Wherefore although the practicall performance of this Probleme for finding the Circumference of the Earth, or the quantity of a Degree on the same, have many singular uses which I cannot now touch; yet that which amongst the rest I chiefly aymed at, was that we might have a more sure and evident ground for dividing the *Log-line*, and for reckoning the Ships way or Distance runne more truly upon any Rumb or Point of the Compasse then formerly.

And now to apply it to this purpose, we have noted before (*Ch. 2.*) that by the Experiment there expressed, we finde in a Degree on the Circumference of Earth and Sea, 367200 of our *English* Feet. Wherefore retayning still the same division of a Degree, into 60 Miles or 20 Leagues (as hath been formerly used) a Mile will containe 6120 Feet, or 1020 Fathomes: And so a League containes 18360 Feet, or 3060 Fathomes; for dividing 367200 by 60, the quotient is 6120, &c. Thus then 60 Miles being a Degree, every Mile is 6120 Feet.

Now supposing the time of the running out of the *Log-line*, to be measured by a halfe-minute glasse, if

we

we observe how many Feet or Fathom she runnes in halfe a minute; we may thereby finde her way for an houre or foure houres, or for any other time proposed.

As admit there runnes out of the *Log-line* in halfe a minutes space 51 Feet, or 8 $\frac{1}{2}$  Fathomes, and you would know what way the Ship makes every houre after the same rate. Say by the Rule of Proportion

If  $0\frac{1}{2}$  Minute, give 51 Feet:

What gives sixty Minutes. Or,

If 1 Minute give 102 Feet:

What gives 60 Minutes?

And so multiplying, you shall finde 6120 Feet, which is one Mile. Or if you would finde her way for foure houres, which is 240 Minutes; say,

As one Minute is in Proportion to 240 minutes,

So are 102 Feet to 24480 Feet, or 4 Miles.

Or if you would have it in Fathomes; say,

As 1 Minute is in Proportion to 240 minutes,

So is 17 Fathomes to 4080 Fathomes, the Ships way in foure houres. The like is to be conceived, if your Glasse be for any other quantity of time above or under halfe a minute.

Some have thought that the way which the Ship maketh, may be knowne to an old Sea-man by experience (as they say) that is by conjecture: Which opinion, makes some neglect the use of the *Log*, lest they should be accounted yong Sea-men. But as hee that rides often will have some neare guesse how farre the Pace he rides will carry him in an houre (because he hath often observed it formerly) so he which hath often sayled and kept an account of the Ships way by the *Log*, will be able to give some neare estimate of her way without the *Log*. But it is incident to some men to have such a conceit of this their estimate, that they thinke it more certaine then the Rule it selfe, from



whence it is derived, especially if it chance to answer their expectations at some times.

It is thought also that the Ships way may be knowne by two markes on the Ships side, but this is doubtlesse very uncertaine, both by reason of the shortnesse of the time, and in respect of the dead water (as they call it) by the Ships side. For the water which is neere the Ship is drawne along with the Ship in her motion, and so much the more by how much it is neerer.

But if any desire to make tryall of this way, It is to be considered, that 17 foote is  $\frac{1}{8}$  part of a mile; and 10 *seconds* of a Minute is  $\frac{1}{12}$  part of an Houre; therefore, if there be two markes on the Ship side distant 17 feete, if the Ship runne the distance of these two markes in 10 *seconds*, shee runnes a Mile an houre, if in 5 *sec.* two miles an houre, if shee runne that distance in 2 *seconds*, shee runnes 5 miles an houre. And so alwayes deviding 10 *seconds* by the number of *seconds* in which the Ship runnes that distance; the Quotient shewes the miles and parts of a mile runne in an houre.

But if the distance of those two marks be 34 Feet, if shee runne it in 20 *sec.* it is after a mile an houre, if in 10, *sec.* two miles an houre, if in 5 *sec.* foure miles an houre; And so alwayes deviding 20 *sec.* by the number of seconds in which the Ship runnes that distance, the quotient shewes how many miles the Ship runnes in an houre. As if the Ship runne that distance of 34 Feete in 8 *seconds*, then deviding 20 by 8, the quotient is  $2\frac{1}{2}$ . Shewing that shee runnes  $2\frac{1}{2}$  miles in an houre. Or if you can conveniently make the distance of the two marks on the Ship side to be 51 Feet (for the further they are distant, the better) then if the Ship runne that distance in 30 *sec.* it is a mile an houre, if in 10 *sec.* it is 3 miles an houre, and so alwayes

wayes deviding 30 *sec.* by the number of seconds in which the Ship is running that distance, the quotient shewes after that rate how many miles the Ship runnes in an houre.

Otherwise you may doe thus, devide 17 Feet into tenne parts, and set as many of those parts on the Ships side as conveniently you may (which according to the Ships length will be more or fewer.) Then when the Ship runnes, one of those parts in a second of time, it is a mile an houre: when two, it is two miles an houre; when 5, it is 5 miles an houre. And in generall if you devide the number of parts runne by the time of running accounted in seconds, the quotient shewes what number of miles after that rate are runne in an houre.

As if shee runne 30 of those parts in 5 *seconds*, it is 6 miles an houre, for deviding 30 by 5, the quotient is sixe; so if shee runne 42 of those parts in tenne seconds; deviding 42 by 10, the Quotient is  $4\frac{2}{10}$ . which sheweth the Ships way at that time to bee after the rate of foure miles and two tenths of a mile in an houre.

But for keeping this account of time, it may be done either by a Sand-glasse for that purpose, or by pronouncing certaine words or numbers: As the time wherein a man tells twice 60, pronouncing every number as fast as he can conveniently and distinctly, is about a minute, so that the time wherein a man is numbring 60. is halfe a minute or 30 *seconds*, and whilest a man is numbring two (as, one and twenty, two and twenty) is a second, and so whilest a man is numbring from twenty to thirty, is five seconds; from twenty to forty, tenne seconds, &c. but in numbring from one to twenty, you may observe the same times, as in numbring from one and  
twen-



twenty to fortie, and this will not be hard to do, for whilst a man pronounceth one and twenty, two and twenty, three and twenty, &c. there remains a certain impression in the fantasie, whereby a man is able in the same times to pronounce one, two, three, &c. And although this rule of numbring twice 60 for a minutes space be not generall unto all men, because some are swifter or slower in their pronounciation then others: yet after this example, a man making triall, may frame a rule to himselfe whereby hee may come something neere the truth.

But leaving these, wee come to the division of the *Log-line* according to the halfe minute-glasse, which is more usuall and certaine. And considering that halfe a minute is of an houre the  $\frac{1}{120}$  part, therefore the ships way running 51 Feet in halfe a minute, is a mile an houre; if she runne twice so much, that is, 102 Feet in halfe a minute, it is two miles an houre; if thrice so much it is three miles an houre. And in generall how many times 51 Feet she runnes in halfe a minute, so many miles is her way for an houre. Therefore leaving halfe a score Fathom or more from the *Log*, that so it may be out of the *Eddy* of the ships wake, before you begin to account or turne the glasse, if there you make a marke for the beginning, and so 51 Feet from thence a marke of one knot, and 51 Feet further a marke of two knots, and 51 Feet further, (that is 153 Feet from your first marke) another marke of three knots, and so proceeding: looke how many knots are veered out in halfe a minute, so many miles is the ships way for an houre. Now for that which is veered out more above the just measure of a knot or knots, you may allow for every five Feet, the tenth part of a mile almost. As admit she runne five knots and 25 Feet in halfe a minute, then is her way according to  $5\frac{1}{2}$  or five miles and a halfe in an houre, if six knots and ten

tenne Feet, it is 6  $\frac{1}{2}$  miles in an houre, &c.

But according to the common opinion of 5000 Feet to a mile, and 60 such miles to a Degree, there should be something lesse then 7 fathom, namely 41  $\frac{1}{2}$  Feet to a knot.

And although he which veeres the *Log-line* be careful to over-hale it so slacke that it may not draw forwards the *Logge*, yet (no doubt) it doth loose some way, following the Ship a little as it is drawne by the Line, and withall by the *Eddy* of the Ships wake; and sometimes also is cast forwards by the winde and waves, when they come after the Ship: so that for these causes it is like there may sometimes be allowed three or foure fathomes more then is veered out, but this (as a thing mutable and vncertaine) being sometimes more, sometimes lesse cannot be brought to any certaine Rule, but such allowance may be made for it, as a man in his Experience and discretion finds fit.

If you would deuide the *Log-line*, so as it might giue the Ships way in *Centesmes* or the hundreth parts of a Degree, and fit it to a halfe Minute glasse, Then seeing the hundreth part of a degree is 367  $\frac{1}{2}$  Feet, and the  $\frac{1}{10}$  part thereof is 30  $\frac{1}{2}$  Feet; If you begin at the marke at which you meane to turne the glasse, and measure from thence 30 Feet, and 3 fift parts of a Foot, you may there place one knot; And thence againe measuring 30 Feet, and 3 fift parts of a foot, there place two knots; and so proceeding at the end of every thirty feet and three fifts, adding a knot, the number of knots which runne out in halfe a minute, is the number of *centesmes* which the Ship runnes in an houre. As suppose there runne out tenne knots in halfe a minute, then the Ships way is according to ten *centesmes* of a degree in an houre, that is the tenth part of a degree or six miles. And so every three foot



above the just measure of knots is neare the tenth part of a *Centesimo*, or the thousandth part of a Degree. As if there runne out of the *Log line* 5 knots and 12 Feet; then the Ships way for an houre is 5 *centesmes* and 4 tenth parts of a *centesimo*, and the like is to bee understood of others.

And after the forme of these examples, you may divide the *Log-line* for any other quantity of time, more or lesse then halfe a minute, or for any other parts of a degree proposed.

Thus have we handled the devision of the *Log-line*, according to the measure before found of 367200 *English Feet* in a degree; But because (as I have before shewed) the Ships way is commonly more then by the *Log-line* it appears to be: and every man desires to have his reckoning something before his Ship, that he fall not with a place v unexpected; for these and such other causes and for the rotundity of the number, if any man thinke it more safe and convenient in Sea-reckonings, he may abate 1 in 51; and so assigne to a degree onely 360000 Feet, and consequently to a mile 6000 *English Feet*.

And upon this ground, if in halfe a minute there runne out 50 feet of the *Log-line*, it is a mile an houre; and so if 100 Feet runne out in a minute.

For as one minute, is in proportion to 60 minutes: So is 100 Feet, to 6000 Feet.

And so forasmuch as twenty five Feet is  $\frac{1}{24}$  part of a Mile, and 15 seconds is also  $\frac{1}{24}$  part of an Houre; Therefore if there bee two markes on the Ships side distant 25 Feet, if the Ship runne the distance of these two markes in 15 seconds, it is after the rate of a mile an houre; if in 5 seconds, it is 3 miles an houre, and so alwayes deviding 15 seconds by the number of seconds in which the Ship runnes that distance, the Quotient shewes the miles and parts of a mile, runne in

in an houre. But if the distance of these two marks be 50 Foot, then if shee runne it in 30 seconds or halfe a minute, it is a mile an houre, if in 10 seconds, three miles an houre, if in 5 seconds, six miles an houre, (for 30 devided by 5. the quotient is 6.) And so alwayes deviding 30 seconds by the number of seconds in which the Ship runnes that distance, the quotient shewes how many miles shee runnes in an houre. &c.

Otherwise, if you make a marke on the Ships side at every twenty Inches, then when the Ship runnes one of these parts in a second of time, it is a mile an houre, when 5. it is 5 miles an houre: if shee runne 18 of these parts in 3 seconds, it is 6 miles an houre; For deviding 18 by 3, the quotient is 6. And in generall, if you deuide the number of the parts runne by the number of seconds spent in running, the Quotient shewes the Ships way in miles for an houre.

But for deviding the Log-line according to this ground of 6000 Feet in a mile, if you intend to vse it with a halfe Minute-glasse, then because halfe a minute, is  $\frac{1}{120}$  part of an houre, and 50 Feet is also the  $\frac{1}{120}$  part of a mile; therefore when the Ship runnes 50 Feet in halfe a minute, her way is after the rate of a mile an houre, if 100 Feet in halfe a minute, it is two miles an houre, &c.

Therefore halfe a score Fathomes or more from the Logge you may make a marke, and beginning from thence measure 50 Feet, and there make the first knot, and 50 Foot farther two knots, and 50 Feet farther 3 knots, and so proceeding: Looke how many knots runne out in halfe a minute, so many miles is the Ships way for an houre. And every 5 Feet more besides the knots is a tenth part of a mile; As if there runne out 6 knots and 20 Feet in halfe a minute, the Ships way is after the rate of  $6\frac{2}{10}$  miles in an houre. &c.



And so if the Glasse were for any other time more or lesse then halfe a minute, you may make the distance of your knots proportionall. As if it were for twenty seconds, then because twenty seconds is of an houre the  $\frac{1}{3}$  part, I deuide a mile which is 6000 Feet by 180, and the quotient is 33  $\frac{1}{3}$ ; therefore there must be a knot at every 33 Feet and 4 inches.

If your Glasse be 36 seconds, which is  $\frac{1}{10}$  part of an houre, deuide 6000 by 100, the Quotient is 60, shewing that there must be 60 Feet to every knot, and then every sixe Foot over and about the knots is a tenth part of a mile more.

And so it is better that your Glasse bee more then halfe a minute rather then lesse, and the more the better, provided that there runne out no more Line then you may hale in againe without danger of breaking.

Lastly, if you would so deuide the Log-line, that it might shew the Ships way in Centesmes of a Degree, and fit it to an halfe minute glasse: then for as much as the hundreth part of a degree is 3600 Feet, and the  $\frac{1}{100}$  part thereof is 30 Feet: therefore beginning at the marke whereat you intend to turne the glasse, measure from thence 30 Feet and there make one knot, and at 30 Feet farther, two knots, &c. Then looke how many knots runne out in halfe a minute; so many centesmes of a degree is the Ships way for an houre. And so if the glasse be 36 seconds, then every knot must haue 36 Feet, &c.

Now if a man sayling betweene any two places which lye neare East and West one from another, haue kept his reckoning by course and distance, using a Log-line so devided, that it haue a knot at every 7 Fathoms (as many doe) And would reduce the distance of those two places so found to their distance in such miles as there of sixty to a degree, each

contayning (as we haue said) 6000 Feet: The proportion in number of those to these is as 6 to 5; for 6 of them make 5 of these.

As admit a man in his dead reckoning vsing such a *Log-line* as hath a knot at every 7 fathoms, and for every knot running out in halfe a minute, he accounts the Ships way to be so many miles an houre; and according to such a reckoning, suppose he finde the distance of two places to be 1224 miles or 408 leagues; and would know the distance of the same places in miles of 6000 Feet to a mile, which is according to a *Log-line* that hath a knot at every 50 Feet.

Say then by the Rule of proportion;

As the number 6,	— Co: ar: —	9,22185
Is in proportion to 5,	—	0,69897
So is the number of Miles given, 1224	—	3,08778
To the number of Miles required, 1020	—	3,00860

Which 1020 is the distance of those two places in such miles whereof 60 make a degree; Or to find the same in leagues, the proportion is, As 6 to 5 so is 408 leagues to 340 leagues.

And thus may the distances of places be found in such miles whereof 60 make a degree, especially if with the distance expressed in the *Plaine-Chart*, you compare the reckonings of some skilfull Mariners that haue sayled from the one to the other. But thus to endeavour a reformation of the *Plaine-Chart* were a labour to little purpose; For there the correcting of the true scituation of two places in respect of one another, is oftentimes an occasion that the same places are the more falsly scituate in respect of others. Like as if there were two places 8 miles distant, and it were required to place a third three miles from either of them, Heere if we set the third in the middle, it will be foure miles distant from either: but if (attempting to mend that



error) we make the third to be 3 miles from the first, then will it be five miles from the second, And thus vnavoydably, the mending of the one is the marring of the other; because the thing proposed is not possible. And such is the error of the *Plaine* or *Common Sea-chart*, representing the Earth and Sea, not as a Sphæricall, but as a plaine superficies; not as if the Meridians did concur in the Poles, but as if they were alwayes parallel one to another. So that the graduation and projection beeing such, the scituations and distances of places cannot be generally and truly expessed therein.

But the graduation and projection of *Mercators Chart*, agreeing without sensible error with the *Globe*, there may in that be described all or any parts of the world, according to their Longitudes, Latitudes, Courses, and Distances, as truly and farre more conveniently for the Mariners use then upon the *Globe* it selfe; and upon such a *Chart* so described, a reckoning may be truly kept, and any error committed may easily be discerned and amended. Whereas on the *Plaine-Chart* if a man finde his reckoning to disagree, hee is so farre from knowing how to amend it, that he can seldome conjecture where the fault was. The neglect and want of these *Charts* hath bene and is a great imperfection in *Navigation* and *Geography*. For howsoever there be some which doe dayly set forth for saile Mappes of the world, and of the parts thereof, according to this projection: yet to haue them truly such and fit for *Navigation*, requires in the Author or maker of them good knowledge and some competent ability of his owne, or ayd from others, with a greater loue to the truth then to his owne profit, which may induce him to bestow such industry, time and expence, as I haue formerly noted to be requisite in such a worke.

For

For the furtherance whereof, and of the practise of *Navigation* in generall; I shall endeavour in the two next Chapters to shew a methodicall and orderly way of keeping a reckoning at Sea, more distinctly and exactly then hath beene formerly vsed, and such as may aptly be set downe in any *Chart* and applyed in the three principall kinds of Sayling; namely, according to the *Plaine Chart*, or *Mercators*, or according to the Arch of a *Great Circle*. And by a few reckonings truly set downe according to this forme, the Maps of the world and of the parts thereof might be much reformed.

CHAP. VIII.

*A Formall and exact way of setting downe  
and perfecting a Sea-  
reckoning.*



Although the Course and Distance cannot bee so truly and certainly knowne as the Latitude may be: yet wee must endeavour in these also to come as neare the truth as may be, the rather for that some reckonings must necessarily depend wholly upon them. And to that end, those which in their Voyages at Sea have occasion to runne farre upon any Course or courses neare the Meridian, may doe well to make tryall of that which I have formerly set downe, touching the quantity of a Degree on the Earth and Sea in our knowne measure; And especially in *East-Indian* voyages, sayling from the *Lizard* in the West part of *England* to *Cape bon Esperance* in *Africk*, they have opportunity of making an ample experiment hereof.

But



But leaving this to the practise of the skillfull and industrious *Sea-man*, wee come now to shew an orderly and exact way of framing and keeping a reckoning at Sea: for which purpose, I haue made the *Table* following, which sheweth how much a Ship is more Northerly or Southerly, and how much more Easterly or Westerly, by sayling vpon any point or halfe point of the *Compassse*, any number of miles proposed.

The like *Table* I made many yeares since, and taught the vse of it in *Navigation*, whether it were then vsed by any other, I know not, I had it of no man, but this I speake that if any man claime the first making and vse of such an one, he may haue it.

The ground of making this *Table* is the same with the former. For as *Radius* is in proportion to the *Distance runne*: so is the sine Complement of the *Rumbe*, to the distance of North or South: and so is the sine of the *Rumbe*, to the distance of East or West. Therefore heere for 10 miles vpon any of the foure points from the Meridian, we set in the second colume the sine Complement of that points (reduced into degrees) and in the third the sine thereof. As the second rumbe or point from the Meridian, being 22 deg. 30 minutes, the sine Complement thereof which is 92 39. set in the second colume against 10: And the sine thereof 38 17, I set there in the third colume; and having done thus, for 10 miles in every colume, the rest may be easily drawne from them.

As in the second colume, for the first halfe point against 10 miles finding 99 52, I set the halfe thereof; namely 49 76 against 5 miles, and the tenth part thereof, namely 9 95 against 1 mile, which doubled or added to it selfe is 19 90 to be set against two miles, whereto adding the same 9 95, the summe is 29 85 for 3 miles, and so for the rest.

And thus for every point and halfe point from the Meridian

Meridian there are three Columes, In the first where-  
of there is set downe, a number of Miles runne vpon  
that point or halfe point; the second sheweth, how  
much the Latitude is altered; that is, how much you  
are more Southerly or Northerly by running so farre  
vpon that point or halfe point; the third, how much  
you are more Easterly or Westerly by running that  
course and distance.

The Numbers set in every first Colume from 1 to  
10, are also to bee understood from 10 to a 100, or  
from 100 to 1000, and the Figure in the fourth place  
of the second and third Columes answer to the figure  
in the first. As admit a Ship runne South and by West  
(that is (South one point Westerly) 165 Miles) I set

S W. 1. Point,	100	981	195	downe this Number thus; and looking in the Columes of the first <i>Rumbe</i> against 10 (which may bee un- derstood to be 100,)
	60	588	117	
	5	49	10	
	165	161.8	32.2	

I finde against it in the second Colume 981 almost,  
and in the third 195; also against 60 (that is 6.) in  
the first Colume there is 588, in the second, and 117  
in the third: Also against 5 in the first colume, there is  
49 in the second, and almost 10 in the third. These set  
downe and summ'd vp as heere appeareth, shew that  
a Ship running S by W, 165 miles, is to the Southwards  
of the place from whence shee departed 161 miles and  
8 tenth parts of a mile, and to the Westwards 32 miles  
and two tenth parts of a mile. If you desire more ex-  
actnesse you may use all the places, for the first or grea-  
test number which is here 100. As in this second exam-

S W. 1. Point.	100	9808	1950	ple, where the Sou- therly distance is 161 $\frac{83}{100}$ Miles, and the Westerly 32 $\frac{17}{100}$ miles.
	60	5885	1170	
	5	490	97	
	165.	161.83	32.17	

K

A Table



*A Table of the Northing or Southing, Easting or Westing of every Rumbe and halfe rumbe from the Meridian: according to the number of Miles runne upon that Rumbe.*

	$\frac{1}{2}$ Poin	$7\frac{1}{2}$ Po	1 Poin	7 Poin	$1\frac{1}{2}$ Po.	$6\frac{1}{2}$ Po.	2 Poin	6 Poin
M.	05.37 $\frac{1}{2}$	84.22 $\frac{1}{2}$	11.15	78.45	16.52	73.7 $\frac{1}{2}$	22.30	67.30
1	995	98	981	195	957	290	924	383
2	1990	196	1962	390	1914	580	1848	766
3	2986	294	2943	585	2871	870	2772	1148
4	3981	392	3923	780	3827	1161	3696	1531
5	4976	490	4904	975	4784	1451	4620	1914
6	5971	588	5885	1170	5741	1741	5544	2297
7	6966	686	6866	1365	6698	2031	6468	2680
8	7961	784	7846	1560	7655	2321	7392	3062
9	8957	882	8827	1755	8612	2612	8315	3445
10	9952	980	9808	1950	9569	2902	9239	3827

	$2\frac{1}{2}$ Po.	$5\frac{1}{2}$ Po.	3 Poin	5 Poin	$3\frac{1}{2}$ Po.	$4\frac{1}{2}$ Po.	4 Poin	4 Poin
M.	28.7 $\frac{1}{2}$	61.52 $\frac{1}{2}$	33.45	56.15	39.22 $\frac{1}{2}$	50.37 $\frac{1}{2}$	45.00	45.00
1	882	471	831	556	773	634	707	707
2	1754	942	1663	1111	1546	1269	1414	1414
3	2646	1414	2494	1667	2319	1903	2121	2121
4	3528	1885	3326	2222	3092	2538	2828	2828
5	4410	2357	4158	2778	3865	3172	3535	3535
6	5292	2828	4989	3334	4638	3806	4242	4242
7	6174	3300	5820	3890	5411	4440	4949	4949
8	7056	3771	6652	4445	6184	5075	5656	5656
9	7937	4243	7483	5000	6957	5710	6364	6364
10	8819	4714	8315	5556	7730	6344	7071	7071

A larger example may be that before set downe in the last *Probleme* of sayling by a *Great circle* from *Summers Islands* to the *Lizard*, pag. 127.

As admit I sayle from thence, first NE, halfe a point Easterly 600 miles : then NE by E, 300 miles ; East North-east halfe a point Northerly, 495 miles : East NE, 390 miles ; ENE,  $\frac{1}{2}$  point Easterly, 264 miles ; E by N, 210 miles ; East 951 miles ; These Courses and Distances I set downe in such forme as here appeareth ; where in the first colume, there is expressed the Course or Point of the *Compass* upon which a man Sailes : In the 2<sup>d</sup>, the Distance of that *Rumbe* from the *Meridian* ; In the 3<sup>d</sup> colume, the Distance run upon that *Point* ; In the rest, the Difference of *Latitude*, and departure from the *Meridian* in Miles and tenth parts of a mile.

Course.	Rumbe frō Me	Distan. miles.	North.	South	East.	West
NE, $\frac{1}{2}$ P.	North Easterly 4 $\frac{1}{2}$ P.	600	380.6		463.8	
NE, by E.	N East 5 Point	300	166.7		249.4	
ENE, $\frac{1}{2}$ P.	N East 5 $\frac{1}{2}$ P.	400	188.5		352.8	
Po. N.		90	42.4		79.4	
		5	2.4		0.4	
ENE.	N East 6 P.	300	114.8		277.2	
		90	34.4		83.1	
ENE, $\frac{1}{2}$ P.	N East 6 $\frac{1}{2}$ P.	200	058.0		191.4	
Po. E.		60	17.4		57.4	
		4	1.2		3.8	
E by N.	N East 7 P.	200	39.0		196.2	
		10	2.0		0.9	
		900			951.0	
East.	East.	50				
		1				
		3210	1047.4		2919.7	



(In all which is to be conceived, that the *Variations* are allowed) so that at the Foot of this reckoning, I find the sum of the North colume to be  $1047\frac{4}{5}$  miles, and the summe of the East colume 2920 miles almost; the first, namely 1047 miles converted into degrees, is 17 degrees 27 minutes the difference of Latitude, which added to the Latitude of *Summers Ilands* 32 deg. 25 min. (where this reckoning began,) the summe is 49 deg. 52 min. which is the Latitude of this last place where this reckoning endeth. So that according to this account, the Ship is runne into the Latitude of 49 deg. 52 min. and hath altered her Longitude to the Eastwards 2920 miles, of such miles whereof 60 make a degree of a great Circle.

Therefore, if you set downe this reckoning on the *Plaine-Chart*, you must make a point in the *Chart* that may be in the Latitude of 49 deg. 52 min. and to the Eastwards of *Summers Ilands* (where this reckoning began) 2920 miles, that is, you must runne a parallel (with your Compasses or otherwise) on your *Chart* in the Latitude of 49 deg. 52 min. and crosse the same by a Meridian, which may be to the Eastwards of the Meridian of *Summers Ilands* 2920 miles, and so the point of the intersection of this parallel and Meridian, is the Traverse point or point in the *Chart* representing the place where the Ship is in the end of this reckoning.

But if you set downe this reckoning on *Mercators Chart*, you must also find a point, that may be in the Latitude of 49 deg. 52 min. and may likewise be to the Eastwards of *Summers Ilands* 2920 miles, which is done by running with your compasses a parallel in the Latitude of 49 deg. 52 min. and crossing the same by a Meridian which may be to the Eastwards of the Meridian of *Summers Ilands* 2920 miles, the point of the intersection of this parallel with that Meridian is the  
traverse

traverse point, representing in the Chart the place where the Ship then is.

For it is to be conceived in this *Chart*, that the degrees of the Meridian intercepted between the Latitudes of two places, are as a *Scale* for those two places, to measure not onely their difference of *Latitude*, but likewise their distance in their *Rumbe*, as also the distance of their *Meridians*.

But because it often falls out, that in sayling from place to place, a Ship runnes not neare the *Rumbe* of the two places by many hundred miles, especially in sayling by the Arch of a *Great circle*, which is the most exquisite manner of sayling, and wherein a man shifts his course often, and runnes much further in one Latitude then in another, as by the former example may appeare: Therefore once in three or foure dayes, or so often as you alter your course much, you may transerre or set downe your reckoning out of your booke into your *Chart*. As in transferring the former Example, you may set downe the Northing and Easting of every of the courses severally, but for brevities sake we will bring them into three parts, (and so also we shall not much erre.)

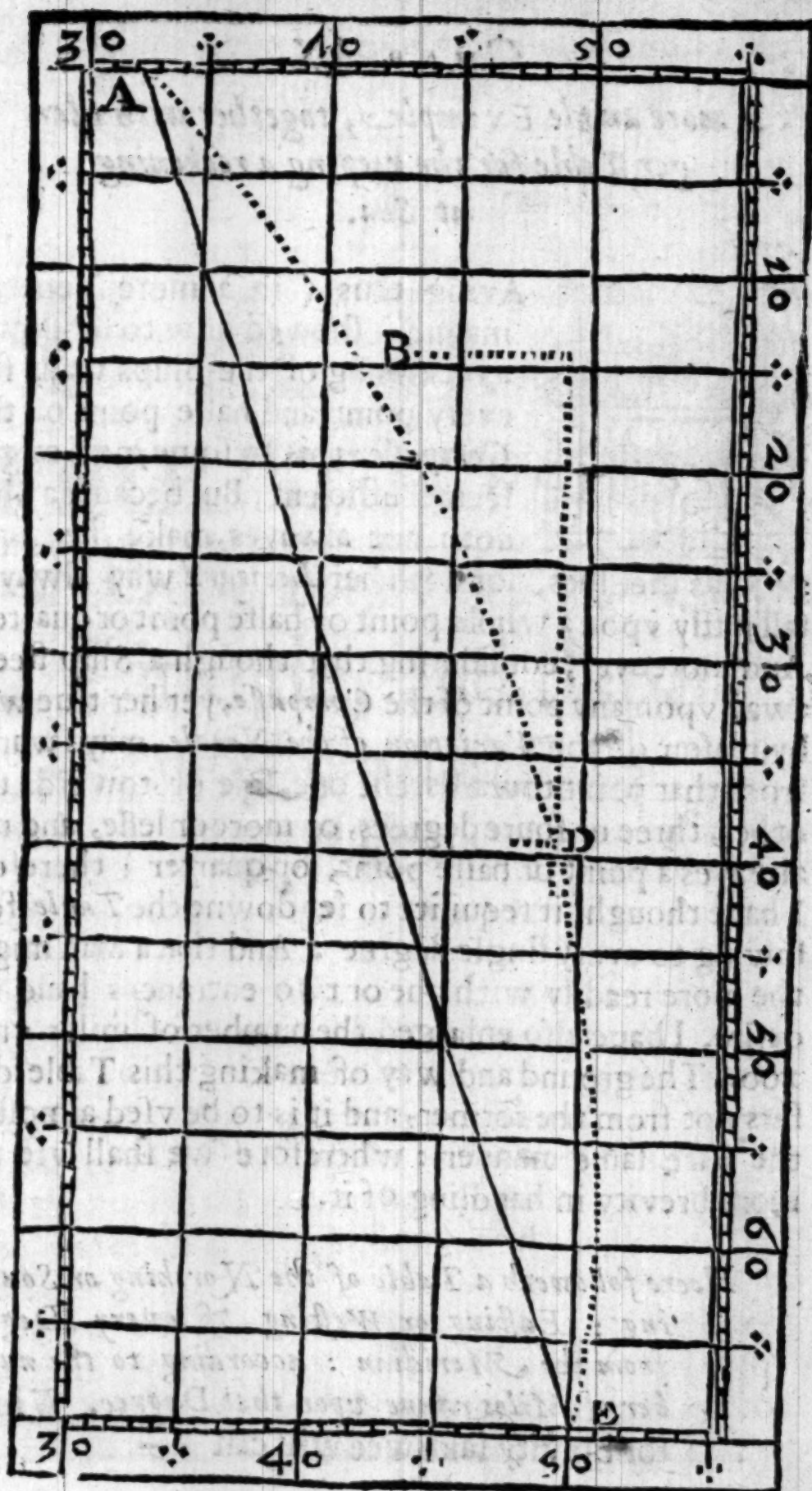
And thus for the two first Courses, namely *N E*,  $\frac{1}{2}$ . point Easterly 600 miles, and *N E* by *E*, 300 miles, I find in the North colume 547 miles, and in the East colume 713 miles. Also for the three next Courses

	North.	East.
summing vp the North and East columes, I finde the Northing to be 459 miles, and the Easting 1050 miles. Also for the two last Courses, I find the Northing to be 41 miles, and the Easting 1157 miles.	547	713
	459	1050
	41	1157
	1047	2920

Now to transerre these into the *Chart*, I consider that 547 miles is 9deg. 7 minutes, which added to the



former Latitude 32 deg. 25 min. makes Latitude 41 deg. 32 min. in which Latitude I runne a parallel, then considering that 713 miles is 11 deg. 53 min. I take this 11 deg. 53 min. in the Meridian, as much about the one Latitude as beneath the other, namely from 31 deg. 00 min. to 42 deg. 53 min. and this I set in the foresaid parallel from the Meridian of *Summers Islands* to the Eastwards, and there make the point *B*, then reducing 459 miles, into degrees, it makes 7 deg. 39 min. which added to 41 deg. 32 min. makes Latitude 49 deg. 11 min. Also the Easting 1050 miles are 17 deg. 30 min. the halfe whereof 8 deg. 45 min. I take in the Meridian from about 41 deg. 32 min. beneath 49 deg. 11 min. namely from 41 deg. 20 min. to 50 deg. 5 min. And this being doubled (because it is but the halfe) I set from the Meridian of the prick or Traverse-point *B* before made, in the parallel of 49 deg. 11 min. making there another prick *D*, Lastly, I adde the Northing 41 miles to the former Latitude 49 deg. 11 min. the summe is 49 deg. 52 min. the Latitude of the parallel, to which I am now come, wherein I am to set downe the Easting 1157 miles; this therefore converted into degrees of a *Great Circle* make 19 deg. 17 min. I take therefore one degree of the Meridian, about that Latitude of 49 deg. 52 min. (because the most part is runne in that Latitude) namely from 49 deg. 30 min. to 50 deg. 30 m. and set the same in the foresaid parallel from the Meridian of the prick *D* last before made to the Eastwards 19 times, and moreover 17 min. taken at the same Latitude, and this reacheth to the point *E*. And so is all this reckoning set downe, and the like is to be understood of any other, which though in expression it require many words for plainnesse: yet is there very little difficulty more in the practise, then there is in setting downe a reckoning on the *Plaine-Chart*.





## CHAP. IX.

*A more ample Example, together with a larger Table for the keeping a reckoning at Sea.*



Having thus (in a more generall manner) showed how to set down a reckoning of the Ships way, for every point and halfe point of the *Compass*, this to some men might seeme sufficient; But because a Ship doth not alwayes make her way good as shee lyes, nor doth her *Leeward* way alwayes fall justly vpon a whole point or halfe point or quarter; And moreover, considering that though a Ship steere away vpon any point of the *Compass*, yet her true way by reason of the *Variation of the Needle* may swarve from that point towards the one side or towards the other, three or foure degrees, or more or lesse, and not alwayes a point or halfe point, or quarter; therefore I haue thought it requisite to set downe the *Table* following to every single degree: And that a man might the more readily with one or two entrances haue his desire, I haue also enlarged the number of miles vnto 100. The ground and way of making this *Table* differs not from the former, and it is to be vsed almost in the selfe same manner: wherefore we shall vse the more brevity in handling of it.

*Heere followeth a Table of the Northing or South-  
ing; Easting or Westing of every Degree  
from the Meridian: according to the num-  
ber of Miles runne vpon that Degree. Which  
for brevity sake wee will call —*

A

A  
TABLE  
FOR THE DIFFERENCE OF  
Latitude, and departure from the *Meridian*.

L

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A  
TABLE  
FOR THE DIF  
FERENCE OF  
Latitude, and de-  
cimum from the Me-  
ridian.

m.	i.d.	89.d.	m.	i.d.	89.d.	min.	i.d.	89.d.
1	10	0	35	350	6	69	690	12
2	20	0	36	360	7	70	700	12
3	30	0	37	370	7	71	710	13
4	40	1	38	380	7	72	720	13
5	50	1	39	390	7	73	730	13
6	60	1	40	400	7	74	740	13
7	70	1	41	410	7	75	750	13
8	80	1	42	420	7	76	760	13
9	90	2	43	430	8	77	770	14
10	100	2	44	440	8	78	780	14
11	110	2	45	450	8	79	790	14
12	120	2	46	460	8	80	800	14
13	130	2	47	470	8	81	810	14
14	140	2	48	480	9	82	820	14
15	150	3	49	490	9	83	830	15
16	160	3	50	500	9	84	840	15
17	170	3	51	510	9	85	850	15
18	180	3	52	520	9	86	860	15
19	190	3	53	530	9	87	870	15
20	200	4	54	540	10	88	880	15
21	210	4	55	550	10	89	890	16
22	220	4	56	560	10	90	900	16
23	230	4	57	570	10	91	910	16
24	240	4	58	580	10	92	920	16
25	250	4	59	590	10	93	930	16
26	260	5	60	600	11	94	940	17
27	270	5	61	610	11	95	950	17
28	280	5	62	620	11	96	960	17
29	290	5	63	630	11	97	970	17
30	300	5	64	640	11	98	980	17
31	310	5	65	650	12	99	990	17
32	320	6	66	660	12	100	1000	18
33	330	6	67	670	12	200	2000	35
34	340	6	68	680	12	300	3000	53



m.	z. d.	88 d	m.	z. d.	88 d	m.	z. d.	88. d
1	10	0	35	350	12	69	690	24
2	20	1	36	360	13	70	700	24
3	30	1	37	370	13	71	710	25
4	40	1	38	380	13	72	720	25
5	50	2	39	390	14	73	730	25
6	60	2	40	400	14	74	740	25
7	70	2	41	410	14	75	750	25
8	80	3	42	420	15	76	760	26
9	90	3	43	430	15	77	770	27
10	100	3	44	440	15	78	780	27
11	110	4	45	450	16	79	790	28
12	120	4	46	460	16	80	800	28
13	130	4	47	470	16	81	809	28
14	140	5	48	480	17	82	819	29
15	150	5	49	490	17	83	829	29
16	160	6	50	500	17	84	839	29
17	170	6	51	510	18	85	849	30
18	180	6	52	520	18	86	859	30
19	190	7	53	530	18	87	869	30
20	200	7	54	540	19	88	879	31
21	210	7	55	550	19	89	889	31
22	220	8	56	560	19	90	899	31
23	230	8	57	570	20	91	909	32
24	240	8	58	580	20	92	919	32
25	250	9	59	590	20	93	929	32
26	260	9	60	600	21	94	939	33
27	270	9	61	610	21	95	949	33
28	280	10	62	620	22	96	959	34
29	290	10	63	630	22	97	969	34
30	300	10	64	640	22	98	979	34
31	310	11	65	650	23	99	989	35
32	320	11	66	660	23	100	999	35
33	330	11	67	670	23	200	1999	70
34	340	12	68	680	24	300	2998	105

m.	2. d	87 d.	m.	3 d	87 d.	m.	2. d.	87. d
1	10		35	350	18	69	689	36
2	20	1	36	360	19	70	699	37
3	30	1	37	370	19	71	709	37
4	40	2	38	380	20	72	719	38
5	50	2	39	390	20	73	729	38
6	60	3	40	400	21	74	739	39
7	70	4	41	410	21	75	749	39
8	80	4	42	420	22	76	759	40
9	90	5	43	430	22	77	769	40
10	100	5	44	440	23	78	779	41
11	110	6	45	450	23	79	789	41
12	120	6	46	460	24	80	799	42
13	130	7	47	470	24	81	809	42
14	140	7	48	480	25	82	819	43
15	150	8	49	490	26	83	829	43
16	160	8	50	500	26	84	839	44
17	170	9	51	509	27	85	849	44
18	180	9	52	519	27	86	859	45
19	190	10	53	529	28	87	869	45
20	200	10	54	539	28	88	879	46
21	210	11	55	549	29	89	889	46
22	220	11	56	559	29	90	899	47
23	230	12	57	569	30	91	909	48
24	240	12	58	579	30	92	919	48
25	250	13	59	589	31	93	929	49
26	260	13	60	599	31	94	939	49
27	270	14	61	609	32	95	949	50
28	280	15	62	619	32	96	959	50
29	290	15	63	629	33	97	969	51
30	300	16	64	639	33	98	979	51
31	310	16	65	649	34	99	989	52
32	320	17	66	659	35	100	999	52
33	330	17	67	669	35	200	1997	105
34	340	18	68	679	36	300	2996	157



m.	4. d.	86 d.	m.	4. d.	86 d.	m.	4. d.	86. d.
1	10	1	35	349	25	69	688	48
2	20	1	36	359	25	70	698	49
3	30	2	37	369	26	71	708	50
4	40	3	38	379	27	72	718	50
5	50	3	39	389	27	73	728	51
6	60	4	40	399	28	74	738	52
7	70	5	41	409	29	75	748	52
8	80	6	42	419	29	76	758	53
9	90	6	43	429	30	77	768	54
10	100	7	44	439	31	78	778	55
11	110	8	45	449	31	79	788	55
12	120	8	46	459	32	80	798	56
13	130	9	47	469	33	81	808	57
14	140	10	48	479	34	82	818	57
15	150	10	49	489	34	83	828	58
16	160	11	50	499	35	84	838	59
17	170	12	51	509	36	85	848	59
18	180	13	52	519	36	86	858	60
19	190	13	53	529	37	87	868	61
20	200	14	54	539	38	88	878	61
21	209	15	55	549	38	89	888	62
22	219	15	56	559	39	90	898	63
23	229	16	57	569	40	91	908	63
24	239	17	58	579	40	92	918	64
25	249	17	59	589	41	93	928	65
26	259	18	60	599	42	94	938	66
27	269	19	61	609	43	95	948	66
28	279	20	62	619	43	96	958	67
29	289	20	63	629	44	97	968	68
30	299	21	64	639	45	98	978	68
31	309	22	65	648	45	99	988	69
32	319	22	66	658	46	100	998	70
33	329	23	67	668	47	200	1995	140
34	339	24	68	678	48	300	2992	209

m.	5. d.	85 c.	m.	5. d.	85 d.	min.	5. d.	85. d.
1	10	1	35	349	30	69	687	60
2	20	2	36	359	31	70	697	61
3	30	3	37	369	32	71	707	62
4	40	3	38	379	33	72	717	63
5	50	4	39	388	34	73	727	64
6	60	5	40	398	35	74	737	65
7	70	6	41	408	36	75	747	65
8	80	7	42	418	37	76	757	66
9	90	8	43	428	37	77	767	67
10	100	9	44	438	38	78	777	68
11	110	10	45	448	39	79	787	69
12	120	10	46	458	40	80	797	70
13	130	11	47	468	41	81	807	71
14	140	12	48	478	42	82	817	71
15	150	13	49	488	43	83	827	72
16	159	14	50	498	44	84	837	73
17	169	15	51	508	45	85	847	74
18	179	16	52	518	45	86	857	75
19	189	17	53	528	46	87	867	76
20	199	17	54	538	47	88	877	77
21	209	18	55	548	48	89	887	78
22	219	19	56	558	49	90	897	78
23	229	20	57	568	50	91	907	79
24	239	21	58	578	51	92	916	80
25	249	22	59	588	52	93	926	81
26	259	23	60	598	52	94	936	82
27	269	24	61	608	53	95	946	83
28	279	24	62	618	54	96	956	84
29	289	25	63	628	55	97	966	84
30	299	26	64	638	56	98	976	85
31	309	27	65	648	57	99	986	86
32	319	28	66	658	58	100	996	87
33	329	29	67	668	58	200	1992	174
34	339	30	68	677	59	300	2989	262



m.	6. d.	84 d.	m.	6. d.	84 d.	min.	6. d.	84 d.
1	10	1	35	348	36	69	686	72
2	20	2	36	358	38	70	696	73
3	30	3	37	368	39	71	706	74
4	40	4	38	378	40	72	716	75
5	50	5	39	388	41	73	726	76
6	60	6	40	398	42	74	736	77
7	70	7	41	408	43	75	746	78
8	80	8	42	418	44	76	756	79
9	89	9	43	428	45	77	766	80
10	99	10	44	438	46	78	776	81
11	109	11	45	447	47	79	786	82
12	119	12	46	457	48	80	796	83
13	129	14	47	467	49	81	806	85
14	139	15	48	477	50	82	815	86
15	149	16	49	487	51	83	825	87
16	159	17	50	497	52	84	835	88
17	169	18	51	507	53	85	845	89
18	179	19	52	517	54	86	855	90
19	189	20	53	527	55	87	865	91
20	199	21	55	537	56	88	875	92
21	209	22	54	547	57	89	885	93
22	219	23	56	557	58	90	895	94
23	229	24	57	567	59	91	905	95
24	239	25	58	577	61	92	915	96
25	249	26	59	587	62	93	925	97
26	259	27	60	597	63	94	935	98
27	265	28	61	607	64	95	945	99
28	278	29	62	617	65	96	955	100
29	288	30	63	627	66	97	965	101
30	298	31	64	637	67	98	975	102
31	308	32	65	646	68	99	985	103
32	318	33	66	656	69	100	995	104
33	328	34	67	666	70	200	1989	209
34	338	35	68	676	71	300	2983	313

m.	7. d.	83 d.	m.	7 d.	83 d.	m.	7. d.	83. d.
1	10	1	35	347	43	69	685	84
2	20	2	36	357	44	70	695	85
3	30	4	37	367	45	71	705	87
4	40	5	38	377	46	72	715	88
5	50	6	39	387	48	73	725	89
6	60	7	40	397	49	74	734	90
7	69	8	41	407	50	75	744	92
8	79	10	42	417	51	76	754	93
9	89	11	43	427	52	77	764	94
10	99	12	44	437	54	78	774	95
11	109	13	45	447	55	79	784	96
12	119	15	46	456	56	80	794	98
13	129	16	47	466	57	81	804	99
14	139	17	48	476	59	82	814	100
15	149	18	49	486	60	83	824	101
16	159	20	50	496	61	84	834	103
17	169	21	51	506	62	85	844	104
18	179	22	52	516	63	86	854	105
19	189	23	53	526	65	87	863	106
20	199	24	54	536	66	88	873	107
21	208	26	55	546	67	89	883	109
22	218	27	56	556	68	90	893	110
23	228	28	57	566	69	91	903	111
24	238	29	58	576	71	92	913	112
25	248	30	59	586	72	93	923	113
26	258	32	60	596	73	94	933	115
27	268	33	61	605	74	95	943	116
28	278	34	62	615	76	96	953	117
29	288	35	63	625	77	97	963	118
30	298	37	64	635	78	98	973	120
31	308	38	65	645	79	99	983	121
32	318	39	66	655	81	100	993	122
33	327	40	67	665	82	200	1985	244
34	337	41	68	675	83	300	2977	366



m.	8. d.	82 d.	m.	8 d.	82 d.	m.	8. d.	82. d.
1	10	1	35	347	49	69	683	56
2	20	2	36	357	50	70	693	97
3	30	4	37	366	51	71	703	99
4	40	6	38	376	53	72	713	100
5	50	7	39	386	54	73	723	102
6	59	8	40	396	56	74	733	103
7	69	10	41	406	57	75	743	104
8	79	11	42	416	58	76	753	106
9	89	13	43	426	60	77	763	107
10	99	14	44	436	61	78	772	109
11	109	15	45	446	63	79	782	110
12	119	17	46	456	64	80	792	111
13	129	18	47	465	65	81	802	113
14	139	19	48	475	67	82	812	114
15	148	21	49	485	68	83	822	115
16	158	22	50	495	70	84	832	117
17	168	24	51	505	71	85	842	118
18	178	25	52	515	72	86	852	120
19	188	26	53	525	74	87	862	121
20	198	28	54	535	75	88	872	122
21	208	29	55	545	77	89	881	124
22	218	31	56	555	78	90	891	125
23	228	32	57	565	79	91	901	127
24	238	33	58	574	81	92	911	128
25	248	35	59	584	82	93	921	129
26	257	36	60	594	83	94	931	131
27	267	38	61	604	85	95	941	132
28	277	39	62	614	86	96	951	134
29	287	40	63	624	88	97	961	135
30	297	42	64	634	89	98	970	136
31	307	43	65	644	90	99	980	138
32	317	44	66	654	92	100	990	139
33	327	46	67	664	93	200	1981	278
34	337	47	68	673	95	300	2971	418

m.	g.d.	81 d.	m.	g.d.	81 l.	min.	g. d.	81 d.
1	10	2	35	346	55	69	682	108
2	20	3	36	356	56	70	691	109
3	30	5	37	366	58	71	701	111
4	40	6	38	375	59	72	711	112
5	49	8	39	385	61	73	721	114
6	59	9	40	395	63	74	731	116
7	69	11	41	405	64	75	741	117
8	79	13	42	415	66	76	751	119
9	89	14	43	425	67	77	761	120
10	99	16	44	435	69	78	770	122
11	109	17	45	445	70	79	780	124
12	119	19	46	454	72	80	790	125
13	129	20	47	464	73	81	800	127
14	138	22	48	474	75	82	810	128
15	148	23	49	484	77	83	820	130
16	158	25	50	494	78	84	830	131
17	168	26	51	504	80	85	840	133
18	178	28	52	514	81	86	850	134
19	188	30	53	524	83	87	859	136
20	198	31	54	534	84	88	869	138
21	208	33	55	543	86	89	879	139
22	217	34	56	553	88	90	889	141
23	227	36	57	563	89	91	899	142
24	237	37	58	573	91	92	909	144
25	247	39	59	583	92	93	919	145
26	257	41	60	593	94	94	929	147
27	267	42	61	603	95	95	938	148
28	277	44	62	612	97	96	948	150
29	287	45	63	622	98	97	958	152
30	296	47	64	632	100	98	968	153
31	306	48	65	642	102	99	978	155
32	316	50	66	652	103	100	988	156
33	326	51	67	662	105	200	1975	213
34	336	53	68	672	106	300	2963	369



m.	10.d	80.d	m.	10.d	80.d	min.	10.d	80.d
1	10	2	35	345	61	69	680	120
2	20	3	36	355	62	70	689	121
3	30	5	37	365	64	71	699	123
4	39	7	38	374	66	72	709	125
5	49	9	39	384	68	73	719	127
6	55	10	40	394	69	74	729	128
7	69	12	41	404	71	75	739	130
8	79	14	42	414	73	76	749	132
9	89	16	43	424	75	77	758	133
10	99	17	44	433	76	78	768	135
11	108	19	45	443	78	79	778	137
12	118	21	46	453	80	80	788	139
13	128	23	47	463	81	81	798	141
14	138	24	48	473	83	82	808	142
15	148	26	49	483	85	83	817	144
16	158	28	50	492	87	84	827	146
17	168	30	51	502	88	85	837	148
18	177	31	52	512	90	86	847	149
19	187	33	53	522	92	87	857	151
20	197	35	55	532	94	88	867	153
21	207	36	54	542	95	89	876	154
22	217	38	56	552	97	90	886	156
23	227	40	57	561	99	91	896	158
24	236	42	58	571	101	92	906	160
25	246	43	59	581	102	93	916	161
26	256	45	60	591	104	94	926	163
27	266	47	61	601	106	95	936	165
28	276	49	62	611	108	96	946	167
29	286	50	63	620	109	97	955	168
30	296	52	64	630	111	98	965	170
31	305	54	65	640	113	99	975	172
32	315	55	66	650	115	100	985	174
33	325	57	67	660	116	200	1970	347
34	333	59	68	670	118	300	2954	521

m.	II d.	79 d.	m.	II d.	79 d.	m.	II d.	79 d.
1	10	2	35	343	67	69	677	132
2	20	4	36	353	69	70	687	134
3	29	6	37	363	71	71	697	135
4	39	8	38	373	72	72	707	137
5	49	9	39	383	74	73	716	139
6	59	11	40	393	76	74	726	141
7	69	13	41	403	78	75	736	143
8	78	15	42	412	80	76	746	145
9	88	17	43	422	82	77	756	147
10	98	19	44	432	84	78	765	149
11	108	21	45	442	86	79	775	151
12	118	23	46	452	88	80	785	153
13	128	25	47	461	90	81	795	154
14	137	27	48	471	92	82	805	156
15	147	29	49	481	93	83	815	158
16	157	30	50	491	95	84	824	160
17	167	32	51	501	97	85	834	162
18	177	34	52	510	99	86	844	164
19	186	36	53	520	101	87	854	166
20	196	38	54	530	103	88	864	168
21	206	40	55	540	105	89	873	170
22	216	42	56	550	107	90	883	172
23	226	44	57	559	109	91	893	174
24	236	46	58	569	111	92	903	176
25	245	48	59	579	112	93	913	177
26	255	50	60	589	114	94	923	179
27	265	51	61	599	116	95	932	181
28	275	53	62	609	118	96	942	183
29	285	55	63	618	120	97	952	185
30	294	57	64	628	122	98	962	187
31	304	59	65	638	124	99	972	189
32	314	61	66	648	126	100	981	191
33	324	63	67	658	128	200	1963	382
34	334	65	68	668	130	300	2944	572



m.	12.d	78.d	m	12.d	78.d	min	12.d	78.d
1	10	2	35	342	73	69	675	144
2	20	4	36	352	75	70	985	146
3	29	6	37	362	77	71	694	148
4	39	8	38	372	79	72	704	150
5	49	10	39	381	81	73	714	152
6	59	12	40	391	83	74	724	154
7	68	15	41	401	85	75	734	156
8	78	17	42	411	87	76	742	158
9	88	19	43	420	90	77	753	160
10	98	21	44	430	92	78	763	162
11	108	23	45	440	94	79	773	164
12	117	25	46	450	96	80	783	166
13	127	27	47	460	98	81	792	168
14	137	29	48	470	100	82	802	170
15	147	31	49	479	102	83	812	173
16	156	33	50	489	104	84	822	175
17	166	36	51	499	106	85	831	177
18	176	38	52	509	108	86	841	179
19	186	40	53	518	110	87	851	181
20	199	42	54	528	112	88	861	183
21	205	44	55	538	114	89	871	185
22	215	46	56	548	116	90	880	187
23	225	48	57	558	118	91	890	189
24	235	50	58	567	121	92	900	191
25	245	52	59	577	123	93	910	193
26	254	54	60	587	125	94	920	195
27	264	56	61	597	127	95	929	197
28	274	58	62	607	129	96	939	200
29	284	60	63	616	131	97	949	202
30	293	62	64	626	133	98	959	204
31	303	64	65	636	135	99	968	206
32	313	66	66	646	137	100	978	208
33	323	69	67	655	140	200	1956	416
34	333	71	68	665	142	200	2934	624

m.	13. d.	77. d.	m.	13. d.	77. d.	m.	13. d.	77. d.
1	10	2	35	341	79	69	672	155
2	20	4	36	351	81	70	682	157
3	29	7	37	361	83	71	692	160
4	39	9	38	370	86	72	702	162
5	49	11	39	380	88	73	711	164
6	59	13	40	390	90	74	721	166
7	68	16	41	400	92	75	731	169
8	78	18	42	409	94	76	741	171
9	88	20	43	419	97	77	750	173
10	98	22	44	429	99	78	760	175
11	107	25	45	438	101	79	770	178
12	117	27	46	448	103	80	780	180
13	127	29	47	458	106	81	789	182
14	136	31	48	468	108	82	799	184
15	146	34	49	477	110	83	809	187
16	156	36	50	487	112	84	818	189
17	166	38	51	497	115	85	828	191
18	176	40	52	507	117	86	838	193
19	185	43	53	516	119	87	848	196
20	195	45	54	526	121	88	857	198
21	205	47	55	536	124	89	867	200
22	215	49	56	546	126	90	877	202
23	224	52	57	555	128	91	887	205
24	234	54	58	565	130	92	896	207
25	244	56	59	575	133	93	906	209
26	254	58	60	585	135	94	916	211
27	263	61	61	594	137	95	926	214
28	273	63	62	604	140	96	935	216
29	283	65	63	614	142	97	945	218
30	292	67	64	624	144	98	955	221
31	302	70	65	634	146	99	965	223
32	312	72	66	643	148	100	974	225
33	322	74	67	653	151	200	1949	450
34	331	76	68	663	153	300	2923	675



m.   14 d.   76 d)			m.   14 d.   76 d)			m.   14 d.   76 d)		
1	10	2	35	340	85	69	669	167
2	19	5	36	349	87	70	679	169
3	29	7	37	359	90	71	689	172
4	39	10	38	369	92	72	698	174
5	48	12	39	378	94	73	708	177
6	58	14	40	388	97	74	718	179
7	68	17	41	398	99	75	728	182
8	78	19	42	407	102	76	737	184
9	87	22	43	417	104	77	747	187
10	97	24	44	427	107	78	757	189
11	107	27	45	437	109	79	766	191
12	116	29	46	446	111	80	776	194
13	126	31	47	456	114	81	786	195
14	136	34	48	466	116	82	796	197
15	146	36	49	475	119	83	805	200
16	155	39	50	485	121	84	815	202
17	165	41	51	495	123	85	825	205
18	175	44	52	504	126	86	834	207
19	184	46	53	514	128	87	844	209
20	194	48	54	524	131	88	854	213
21	204	51	55	534	133	89	864	215
22	213	53	56	543	136	90	873	218
23	223	56	57	553	138	91	883	220
24	233	58	58	563	140	92	893	223
25	242	60	59	572	143	93	902	225
26	252	63	60	582	145	94	912	227
27	262	65	61	592	148	95	921	230
28	272	68	62	601	150	96	931	232
29	281	70	63	611	153	97	941	235
30	291	73	64	621	155	98	951	237
31	301	75	65	631	157	99	960	240
32	310	77	66	640	160	100	970	242
33	320	80	67	650	162	200	1941	484
34	330	82	68	660	165	300	2911	726

m.	15.d.	75 d.	m.	15.d.	75 d.	min.	15. d.	75.d.
1	10	3	35	338	91	69	666	179
2	19	5	36	348	93	70	676	181
3	29	8	37	357	96	71	686	184
4	39	10	38	367	98	72	696	186
5	48	13	39	377	101	73	705	189
6	58	16	40	386	103	74	715	192
7	68	18	41	396	106	75	724	194
8	77	21	42	405	109	76	734	197
9	87	23	43	415	111	77	744	200
10	97	26	44	425	114	78	754	202
11	106	28	45	435	116	79	763	205
12	116	31	46	444	119	80	773	207
13	126	34	47	454	123	81	783	210
14	135	36	48	464	125	82	792	212
15	145	39	49	473	128	83	802	215
16	155	41	50	483	129	84	811	217
17	164	44	51	493	132	85	821	220
18	174	47	52	502	135	86	831	223
19	183	49	53	512	137	87	840	225
20	193	52	55	522	140	88	850	228
21	203	54	54	531	142	89	860	230
22	213	57	56	541	145	90	869	233
23	222	60	57	551	148	91	879	236
24	233	62	58	560	150	92	889	238
25	242	65	59	570	153	93	898	241
26	251	67	60	580	155	94	908	243
27	261	70	61	589	158	95	918	246
28	271	73	62	599	160	96	927	248
29	280	75	63	608	163	97	937	251
30	290	78	64	618	166	98	947	254
31	299	80	65	628	168	99	956	256
32	309	83	66	638	171	100	966	259
33	319	85	67	647	174	200	1932	518
34	328	88	68	657	176	300	2898	776



m	16.d	74.d	m	16.d	74.d	min.	16.d.	74.d.
1	10	3	35	336	97	60	663	190
2	19	6	36	346	99	70	673	193
3	29	8	37	356	102	71	682	196
4	38	11	38	365	105	72	692	199
5	48	14	39	375	107	73	702	201
6	58	17	40	384	110	74	711	204
7	67	19	41	394	113	75	721	207
8	77	22	42	404	116	76	731	210
9	86	25	43	413	119	77	740	213
10	96	28	44	423	121	78	750	215
11	106	30	45	432	124	79	759	218
12	115	33	46	442	127	80	769	220
13	125	36	47	452	130	81	779	223
14	134	39	48	461	132	82	788	226
15	144	41	49	471	135	83	798	229
16	154	44	50	481	138	84	807	232
17	163	47	51	490	141	85	817	235
18	173	50	52	500	143	86	827	237
19	183	53	53	509	146	87	836	240
20	192	55	54	519	149	88	846	243
21	202	58	55	529	151	89	856	245
22	211	61	56	538	154	90	865	248
23	222	63	57	548	157	91	875	251
24	231	66	58	557	160	92	884	254
25	240	69	59	567	163	93	894	257
26	250	72	60	577	165	94	904	259
27	259	75	61	586	168	95	913	262
28	269	77	62	596	171	96	923	265
29	279	80	63	606	174	97	932	267
30	288	83	64	615	177	98	942	270
31	298	85	65	625	179	99	952	273
32	308	88	66	634	182	100	961	276
33	317	91	67	644	185	200	1923	551
34	327	94	68	654	188	300	2884	827

m.	17 d.	73 d.	m.	17 d.	73 d.	m.	17 d.	73 d.
1	10	3	35	335	102	69	660	202
2	19	6	36	344	105	70	669	205
3	29	9	37	354	108	71	979	207
4	38	12	38	363	111	72	688	210
5	48	15	39	373	114	73	698	213
6	57	17	40	383	117	74	708	216
7	67	20	41	392	120	75	717	219
8	76	23	42	402	123	76	727	222
9	86	26	43	411	126	77	736	225
10	96	29	44	421	129	78	746	228
11	105	32	45	430	131	79	755	231
12	115	35	46	440	134	80	765	234
13	124	38	47	449	137	81	775	237
14	134	41	48	459	140	82	784	240
15	143	44	49	469	143	83	794	243
16	153	47	50	478	146	84	802	246
17	162	50	51	488	149	85	813	248
18	172	52	52	497	152	86	822	251
19	182	55	53	507	155	87	832	254
20	191	58	54	516	158	88	842	257
21	201	61	55	526	161	89	851	260
22	210	64	56	535	164	90	861	263
23	220	67	57	545	167	91	870	266
24	230	70	58	554	170	92	880	269
25	239	73	59	564	172	93	889	272
26	249	76	60	574	175	94	899	275
27	258	79	61	583	178	95	908	278
28	268	82	62	593	181	96	918	281
29	277	85	63	602	184	97	927	284
30	287	88	64	612	187	98	937	287
31	296	91	65	622	190	99	947	289
32	306	93	66	631	193	100	956	292
33	316	96	67	641	196	200	1913	585
34	325	99	68	650	199	300	2869	877



m	18 d	72 d	m	18 d	72 d	m	18 d	72 d
1	10	3	35	333	108	69	656	213
2	19	6	36	342	111	70	666	216
3	28	9	37	352	114	71	675	219
4	38	12	38	361	117	72	685	222
5	47	15	39	371	120	73	694	225
6	57	18	40	380	124	74	704	229
7	66	22	41	390	127	75	713	232
8	76	25	42	398	130	76	723	235
9	85	28	43	408	133	77	732	238
10	95	31	44	417	136	78	742	241
11	104	34	45	427	139	79	751	244
12	114	37	46	436	142	80	761	247
13	123	40	47	446	145	81	770	250
14	133	43	48	455	148	82	780	253
15	142	46	49	465	151	83	789	256
16	152	50	50	476	154	84	799	260
17	161	53	51	485	158	85	808	263
18	171	56	52	495	161	86	818	266
19	180	59	53	504	164	87	827	269
20	190	62	54	514	167	88	837	272
21	200	65	55	523	170	89	846	275
22	209	68	56	533	173	90	856	278
23	219	71	57	542	176	91	865	281
24	228	74	58	552	179	92	875	284
25	238	77	59	561	182	93	884	287
26	247	81	60	571	185	94	894	290
27	257	84	61	580	188	95	903	293
28	266	87	62	590	192	96	913	297
29	276	90	63	599	195	97	922	300
30	285	93	64	609	198	98	932	303
31	295	96	65	618	201	99	941	306
32	304	99	66	628	204	100	951	309
33	314	102	67	637	207	200	1902	618
34	323	105	68	647	210	300	2852	927

m	19 d	71 d	m	19 d	71 d	min.	19 d	71 d
1	91	3	35	331	114	69	652	225
2	19	6	36	340	117	70	662	228
3	28	10	37	350	121	71	671	231
4	38	13	38	359	124	72	681	234
5	47	16	39	369	127	73	690	238
6	57	20	40	378	130	74	699	241
7	66	23	41	388	134	75	709	244
8	75	26	42	397	137	76	718	247
9	85	29	43	407	140	77	728	251
10	94	33	44	416	143	78	737	254
11	104	36	45	425	147	79	747	257
12	113	39	46	435	150	80	756	261
13	123	42	47	444	153	81	766	264
14	132	46	48	454	156	82	775	267
15	142	49	49	463	160	83	785	270
16	151	52	50	473	163	84	794	274
17	161	55	51	482	166	85	804	277
18	170	59	52	492	169	86	813	280
19	180	62	53	501	173	87	822	283
20	189	65	54	510	176	88	831	287
21	199	68	55	520	179	89	841	290
22	208	72	56	529	182	90	851	293
23	217	75	57	539	186	91	860	296
24	227	78	58	548	189	92	870	300
25	236	82	59	558	192	93	879	303
26	246	85	60	567	195	94	889	306
27	255	88	61	577	199	95	898	309
28	265	91	62	586	202	96	908	313
29	274	94	63	596	205	97	917	316
30	284	98	64	605	208	98	926	313
31	293	101	65	615	212	99	936	322
32	303	104	66	624	215	100	945	326
33	312	107	67	634	218	200	1891	651
34	321	111	68	643	222	300	2836	977



m.	20 d.	70 d.	m.	20 d.	70 d.	m.	20 d.	70 d.
1	9	3	35	329	120	69	648	236
2	19	7	36	338	123	70	658	239
3	28	10	37	348	126	71	667	243
4	38	14	38	357	130	72	677	246
5	47	17	39	366	133	73	686	250
6	56	20	40	376	137	74	695	253
7	66	24	41	385	140	75	705	256
8	75	27	42	395	144	76	714	260
9	85	31	43	404	147	77	724	263
10	94	34	44	413	150	78	733	267
11	103	38	45	423	154	79	742	270
12	113	41	46	432	157	80	752	274
13	122	44	47	442	161	81	761	277
14	132	48	48	451	164	82	771	280
15	141	51	49	460	168	83	780	284
16	150	55	50	470	171	84	789	287
17	160	58	51	479	174	85	800	291
18	169	61	52	489	178	86	808	294
19	179	65	53	498	181	87	818	298
20	188	68	55	507	185	88	827	301
21	197	72	54	517	188	89	836	304
22	207	75	56	526	191	90	846	308
23	216	79	57	536	195	91	855	311
24	226	82	58	545	198	92	864	315
25	235	85	59	554	202	93	874	318
26	244	89	60	564	205	94	883	321
27	254	92	61	573	209	95	893	325
28	263	96	62	583	212	96	902	328
29	272	109	63	592	215	97	912	332
30	282	103	64	601	219	98	921	335
31	291	106	65	611	222	99	930	339
32	301	109	66	620	226	100	940	342
33	310	113	67	630	229	200	1879	684
34	319	116	68	639	233	300	2819	1026

m.	21.d	69 d	m.	21.d	69 d.	m.	21 d	69.
1	9	4	35	327	125	69	644	247
2	19	7	36	336	127	70	653	251
3	28	11	37	345	132	71	663	254
4	37	14	38	355	136	72	672	258
5	47	18	39	364	140	73	681	262
6	56	21	40	373	143	74	691	265
7	65	25	41	383	147	75	700	269
8	75	29	42	392	150	76	709	272
9	84	32	43	401	154	77	719	276
10	93	36	44	411	158	78	728	279
11	103	39	45	420	161	79	737	283
12	112	43	46	429	165	80	747	287
13	121	47	47	439	168	81	756	290
14	131	50	48	448	172	82	766	294
15	140	54	49	457	176	83	775	297
16	149	57	50	467	179	84	784	301
17	159	61	51	476	183	85	794	305
18	168	64	52	485	186	86	803	308
19	177	68	53	495	190	87	812	312
20	187	72	54	504	193	88	822	315
21	196	75	55	513	197	89	831	319
22	205	79	56	523	201	90	840	323
23	215	82	57	532	204	91	849	326
24	224	86	58	541	208	92	859	330
25	233	90	59	551	211	93	868	333
26	243	93	60	560	215	94	877	337
27	252	97	61	569	219	95	887	340
28	261	100	62	579	222	96	890	344
29	271	104	63	588	226	97	905	348
30	280	107	64	598	229	98	915	351
31	289	111	65	607	233	99	924	355
32	299	115	66	616	236	100	934	358
33	308	118	67	626	240	200	1867	717
34	317	122	68	635	244	300	1801	175



m.	22.d	58 d	m.	22.d	68 d.	m.	22 d.	68. d
1	9	4	35	324	131	69	640	259
2	19	7	36	334	135	70	649	262
3	28	11	37	343	139	71	658	266
4	37	15	38	352	142	72	667	270
5	46	19	39	361	146	73	677	274
6	56	22	40	371	150	74	686	277
7	65	26	41	380	154	75	695	281
8	74	30	42	389	157	76	705	285
9	83	34	43	399	161	77	714	289
10	93	37	44	408	165	78	723	292
11	102	41	45	417	169	79	733	296
12	111	45	46	426	172	80	742	300
13	120	49	47	436	176	81	751	304
14	130	52	48	445	180	82	760	307
15	139	56	49	454	184	83	770	311
16	148	60	50	464	187	84	779	315
17	157	64	51	473	191	85	788	319
18	167	67	52	482	195	86	797	322
19	176	71	53	491	199	87	806	326
20	185	75	54	501	202	88	816	330
21	195	79	55	510	206	89	825	334
22	204	82	56	519	210	90	834	337
23	213	86	57	529	214	91	844	341
24	222	90	58	538	217	92	853	345
25	232	94	59	547	221	93	861	349
26	241	97	60	556	225	94	871	352
27	250	101	61	566	229	95	881	356
28	260	105	62	575	233	96	890	360
29	269	109	63	584	236	97	899	364
30	278	112	64	594	240	98	909	367
31	287	116	65	603	244	99	918	371
32	297	120	66	612	247	100	927	375
33	306	124	67	621	251	200	1054	749
34	315	127	68	631	255	300	2782	1094

m.	23.d	67.d.	m.	23.d	67.d.	m.	23.d.	67.d.
1	9	4	35	323	137	69	635	269
2	18	8	36	331	141	70	644	273
3	28	12	37	340	144	71	653	277
4	37	16	38	350	248	72	663	281
5	46	19	39	359	152	73	672	285
6	55	23	40	368	156	74	681	289
7	64	27	41	377	160	75	690	293
8	74	31	42	386	164	76	699	297
9	83	35	43	396	168	77	709	301
10	92	39	44	405	172	78	718	305
11	101	43	45	414	176	79	727	308
12	110	47	46	423	180	80	736	312
13	120	51	47	433	184	81	746	316
14	129	55	48	442	187	82	755	320
15	138	59	49	451	191	83	764	324
16	147	62	50	460	195	84	773	328
17	156	66	51	469	199	85	782	332
18	166	70	52	479	203	86	792	336
19	175	74	53	488	207	87	801	340
20	184	78	54	497	211	88	810	344
21	193	82	55	506	215	89	819	348
22	202	86	56	515	219	90	828	352
23	212	90	57	524	223	91	838	356
24	221	94	58	534	226	92	847	360
25	230	98	59	543	230	93	856	363
26	239	102	60	552	234	94	865	367
27	248	105	61	561	238	95	874	370
28	258	109	62	571	242	96	884	375
29	267	113	63	580	246	97	893	379
30	276	117	64	589	250	98	902	383
31	285	121	65	598	254	99	911	387
32	294	125	66	608	258	100	920	391
33	304	129	67	618	262	200	1841	781
34	313	133	68	626	266	300	2761	1172



m	24. d.	66 d.	m	24. d.	66 d.	m	24. d.	66. d.
1	9	4	35	320	142	69	630	281
2	18	8	36	329	146	70	639	285
3	27	12	37	338	151	71	648	289
4	36	16	38	347	155	72	658	293
5	46	20	39	356	159	73	667	297
6	55	24	40	365	163	74	676	301
7	64	28	41	374	167	75	685	305
8	73	32	42	384	171	76	694	309
9	82	37	43	393	175	77	703	313
10	91	41	44	402	179	78	712	317
11	100	45	45	411	183	79	721	321
12	109	49	46	420	187	80	731	325
13	119	53	47	429	191	81	740	329
14	128	57	48	438	195	82	749	333
15	137	61	49	448	199	83	758	337
16	146	65	50	457	203	84	767	341
17	155	69	51	466	207	85	776	345
18	164	73	52	475	211	86	785	349
19	173	77	53	484	216	87	795	353
20	183	81	54	493	220	88	804	357
21	192	85	55	502	224	89	813	362
22	201	90	56	511	228	90	822	366
23	210	94	57	521	232	91	831	370
24	219	98	58	530	236	92	840	374
25	228	102	59	539	240	93	849	378
26	237	106	60	548	244	94	858	382
27	246	110	61	557	248	95	868	386
28	256	113	62	566	252	96	877	390
29	265	117	63	575	256	97	886	395
30	274	122	64	585	260	98	895	399
31	283	126	65	594	264	99	904	403
32	292	130	66	603	268	100	913	407
33	301	134	67	612	272	200	1827	813
34	310	138	68	621	276	300	2740	1220

m.	25 d.	65 d.	m.	25 d.	65 d.	m.	25 d.	65 d.
1	9	4	35	317	148	69	625	292
2	18	8	36	326	152	70	634	296
3	27	13	37	335	156	71	643	300
4	36	17	38	344	161	72	652	305
5	45	21	39	353	165	73	662	309
6	54	25	40	362	169	74	671	313
7	63	30	41	372	173	75	680	317
8	72	34	42	381	178	76	689	321
9	81	38	43	390	183	77	698	326
10	91	42	44	399	186	78	707	330
11	100	47	45	408	190	79	716	334
12	109	51	46	417	195	80	725	338
13	118	55	47	426	199	81	734	343
14	127	59	48	435	203	82	743	347
15	136	63	49	444	207	83	752	351
16	145	68	50	453	211	84	761	355
17	154	72	51	462	216	85	770	360
18	163	76	52	471	220	86	779	364
19	172	80	53	480	224	87	788	368
20	181	84	54	489	228	88	797	372
21	190	89	55	498	232	89	807	376
22	199	93	56	507	237	90	816	380
23	208	97	57	516	241	91	825	384
24	218	101	58	526	245	92	834	389
25	227	106	59	535	250	93	843	393
26	236	110	60	544	254	94	852	397
27	245	114	61	553	258	95	861	401
28	254	118	62	562	262	96	870	406
29	263	123	63	571	267	97	879	410
30	272	127	64	580	271	98	888	414
31	281	131	65	589	275	99	897	418
32	290	135	66	598	279	100	906	423
33	299	140	67	607	283	200	1813	845
34	308	144	68	616	288	300	2719	1268



m.	26 d.	64 d.	m.	26 d.	64 d.	m.	26 d.	64 d.
1	9	4	35	315	153	69	629	302
2	18	9	36	324	158	70	629	307
3	27	13	37	333	162	71	638	311
4	36	18	38	342	166	72	647	316
5	45	22	39	351	171	73	656	320
6	54	26	40	360	175	74	665	324
7	63	31	41	468	179	75	674	329
8	72	35	42	378	184	76	683	333
9	81	39	43	380	188	77	692	338
10	90	44	44	395	193	78	701	342
11	99	48	45	404	197	79	710	346
12	108	53	46	413	202	80	719	351
13	117	57	47	422	206	81	728	355
14	126	61	48	431	210	82	737	359
15	135	66	49	440	214	83	746	364
16	144	70	50	449	219	84	755	368
17	153	74	51	458	223	85	764	372
18	162	79	52	467	228	86	773	377
19	171	83	53	476	232	87	782	381
20	180	88	54	485	237	88	791	385
21	189	92	55	494	241	89	800	390
22	198	96	56	503	245	90	809	394
23	207	101	57	512	250	91	818	399
24	216	105	58	521	254	92	827	403
25	225	109	59	530	258	93	836	407
26	234	114	60	539	263	94	845	412
27	243	118	61	548	267	95	854	416
28	252	123	62	557	272	96	863	421
29	261	127	63	566	276	97	872	425
30	270	131	64	575	280	98	881	429
31	279	136	65	584	285	99	890	434
32	288	140	66	593	289	100	899	438
33	297	144	67	602	294	200	1798	877
34	306	149	68	611	298	300	2696	1315

m.	27.d.	63.d.	m.	27.d.	63.d.	min.	27.d.	63.d.
1	9	5	35	312	159	69	615	313
2	18	9	36	321	162	70	624	318
3	27	14	37	330	168	71	633	322
4	36	18	38	338	172	72	641	327
5	45	23	39	347	177	73	650	332
6	53	27	40	356	182	74	659	336
7	62	32	41	365	186	75	668	341
8	71	36	42	374	191	76	677	345
9	80	41	43	383	195	77	686	350
10	89	45	44	391	200	78	695	354
11	98	50	45	401	204	79	704	359
12	107	54	46	410	209	80	713	363
13	116	59	47	419	213	81	722	368
14	125	63	48	428	218	82	731	372
15	134	68	49	436	222	83	739	377
16	143	72	50	445	227	84	748	381
17	151	77	51	454	232	85	757	386
18	160	82	52	463	236	86	766	390
19	169	86	53	472	241	87	775	395
20	178	91	54	481	245	88	784	400
21	187	95	55	490	250	89	793	404
22	196	100	56	499	254	90	802	409
23	205	104	57	508	259	91	811	413
24	214	109	58	517	263	92	820	418
25	223	113	59	526	268	93	829	422
26	232	118	60	535	272	94	837	427
27	241	122	61	543	277	95	846	431
28	249	127	62	552	282	96	855	436
29	258	132	63	561	286	97	864	440
30	267	136	64	570	291	98	873	445
31	276	141	65	579	295	99	882	449
32	285	145	66	588	300	100	891	454
33	294	150	67	597	304	200	1782	909
34	303	154	68	606	309	300	2673	1363



m. / 28.d / 62.d			m. / 28.d / 62.d			min. / 28.d / 62.d		
1	9	5	35	309	164	69	609	324
2	18	9	36	318	169	70	618	329
3	26	14	37	326	174	71	627	333
4	35	19	38	335	178	72	636	338
5	44	23	39	344	183	73	644	343
6	53	28	40	353	188	74	653	347
7	62	33	41	362	192	75	662	352
8	71	37	42	371	197	76	671	357
9	79	42	43	380	202	77	680	361
10	88	47	44	388	207	78	689	366
11	97	52	45	397	211	79	697	371
12	106	56	46	406	216	80	706	376
13	115	61	47	415	221	81	715	380
14	124	66	48	424	225	82	724	385
15	132	70	49	432	230	83	733	390
16	141	75	50	441	235	84	742	394
17	150	80	51	450	239	85	750	399
18	159	84	52	459	244	86	759	404
19	168	89	53	468	249	87	768	408
20	177	94	54	477	254	88	777	413
21	185	99	55	485	258	89	786	418
22	194	103	56	494	263	90	795	422
23	203	108	57	503	268	91	803	427
24	212	113	58	512	272	92	812	432
25	221	117	59	521	277	93	821	437
26	230	122	60	530	282	94	830	441
27	238	127	61	538	286	95	839	446
28	247	131	62	547	291	96	848	451
29	256	136	63	556	296	97	856	455
30	265	141	64	565	300	98	865	460
31	274	145	65	574	305	99	874	465
32	282	150	66	583	310	100	883	469
33	291	155	67	591	315	200	1766	939
34	300	160	68	600	319	300	2649	1408

m.	29.d.	61.d.	m.	29.d.	61.d.	m.n.	29.d.	61.d.
1	9	5	35	316	170	69	604	334
2	17	10	36	315	174	70	612	339
3	26	14	37	324	179	71	621	344
4	35	19	38	332	184	72	630	349
5	44	24	39	341	189	73	638	354
6	52	29	40	350	194	74	647	359
7	61	34	41	359	199	75	656	363
8	70	39	42	367	203	76	665	368
9	79	43	43	376	208	77	673	373
10	87	48	44	385	213	78	682	378
11	96	53	45	394	218	79	691	383
12	105	58	46	402	223	80	700	388
13	114	63	47	411	228	81	708	393
14	122	68	48	420	233	82	717	397
15	131	73	49	429	237	83	726	402
16	140	77	50	437	242	84	735	407
17	149	82	51	446	247	85	743	412
18	157	87	52	455	252	86	752	417
19	166	92	53	464	257	87	761	422
20	175	97	54	472	262	88	770	427
21	184	102	55	481	267	89	778	431
22	192	107	56	490	271	90	787	436
23	201	111	57	499	276	91	796	441
24	210	116	58	507	281	92	805	446
25	219	121	59	516	286	93	813	451
26	227	126	60	525	291	94	822	456
27	236	131	61	534	296	95	831	461
28	245	136	62	542	301	96	840	465
29	254	141	63	551	305	97	848	470
30	262	145	64	560	310	98	857	475
31	271	150	65	569	315	99	866	480
32	280	155	66	577	320	100	875	485
33	289	160	67	586	325	200	1749	970
34	297	165	68	595	330	300	2624	1454



m	30.d	60.d	m	30 d.	60 d.	min.	30. d.	60 d.
1	9	5	35	303	175	69	598	345
2	17	10	36	312	180	70	606	350
3	26	15	37	320	185	71	615	355
4	35	20	38	329	190	72	623	360
5	43	25	39	338	195	73	632	365
6	52	30	40	346	200	74	641	370
7	61	35	41	355	205	75	649	375
8	69	40	42	364	210	76	658	380
9	78	45	43	372	215	77	667	385
10	87	50	44	381	220	78	676	390
11	95	55	45	390	225	79	684	395
12	104	60	46	398	230	80	693	400
13	113	65	47	407	235	81	702	505
14	121	70	48	416	240	82	710	410
15	130	75	49	424	245	83	719	415
16	139	80	50	433	250	84	727	420
17	147	85	51	442	255	85	736	425
18	156	90	52	450	260	86	745	430
19	165	95	53	459	265	87	753	435
20	173	100	54	468	270	88	762	440
21	182	105	55	476	275	89	771	445
22	191	110	56	485	280	90	779	450
23	199	115	57	494	285	91	788	455
24	208	120	58	502	290	92	797	460
25	217	125	59	511	295	93	806	465
26	225	130	60	520	300	94	814	470
27	234	135	61	528	305	95	823	475
28	242	140	62	537	310	96	832	480
29	251	145	63	546	315	97	840	485
30	260	150	64	554	320	98	849	490
31	268	155	65	563	325	99	857	495
32	277	160	66	572	330	100	866	500
33	286	165	67	580	335	200	1732	1000
34	294	170	68	589	340	300	2598	1500

m	31.d.	59.d.	m	31.d.	59.d.	min.	31.d.	59.d.
1	9	5	35	300	180	69	591	355
2	17	10	36	309	185	70	600	360
3	26	15	37	317	191	71	609	366
4	34	21	38	326	196	72	617	371
5	43	26	39	334	201	73	626	376
6	51	31	40	343	206	74	634	381
7	60	36	41	351	211	75	643	386
8	69	41	42	360	216	76	651	391
9	77	46	43	369	221	77	660	397
10	86	51	44	377	227	78	669	402
11	94	57	45	386	232	79	677	407
12	103	62	46	394	237	80	686	412
13	111	67	47	403	242	81	694	417
14	120	72	48	411	247	82	703	422
15	129	77	49	420	252	83	711	427
16	137	82	50	429	257	84	720	433
17	146	88	51	437	263	85	729	438
18	154	93	52	446	268	86	737	443
19	163	98	53	454	273	87	746	448
20	171	103	54	463	278	88	754	453
21	180	108	55	471	283	89	763	458
22	189	113	56	480	288	90	771	463
23	197	118	57	489	294	91	780	469
24	206	124	58	497	299	92	789	474
25	214	129	59	506	304	93	797	479
26	223	134	60	514	309	94	806	484
27	231	139	61	523	314	95	814	489
28	240	144	62	531	319	96	823	494
29	249	149	63	540	324	97	831	500
30	257	154	64	549	330	98	840	505
31	266	160	65	557	335	99	849	510
32	274	165	66	566	340	100	857	515
33	283	170	67	574	345	200	1714	1030
34	292	175	68	583	350	300	2572	1545

[ m ]



m.	32.d.	58.d.	m.	32.d.	58.d.	min.	32.d.	58.d.
1	8	5	35	297	185	69	585	366
2	17	11	36	305	191	70	594	371
3	25	16	37	314	196	71	602	376
4	34	21	38	322	201	72	610	381
5	42	26	39	331	207	73	619	387
6	51	32	40	339	212	74	627	392
7	59	37	41	348	217	75	636	397
8	68	42	42	356	223	76	644	403
9	76	48	43	365	228	77	653	408
10	85	53	44	373	233	78	661	413
11	93	58	45	382	238	79	670	419
12	102	64	46	390	244	80	678	424
13	110	69	47	398	249	81	687	429
14	119	74	48	407	254	82	695	434
15	127	79	49	415	260	83	703	440
16	136	85	50	424	265	84	712	445
17	144	90	51	432	270	85	721	450
18	153	95	52	441	275	86	729	456
19	161	101	53	449	281	87	738	461
20	170	106	54	458	286	88	746	466
21	178	111	55	466	291	89	755	472
22	187	117	56	475	297	90	763	477
23	195	122	57	483	302	91	772	482
24	204	127	58	492	307	92	780	487
25	212	132	59	500	313	93	788	493
26	220	138	60	509	318	94	797	498
27	229	143	61	517	323	95	805	503
28	237	148	62	526	329	96	814	509
29	246	153	63	534	334	97	822	514
30	254	159	64	543	339	98	831	519
31	263	164	65	551	344	99	839	524
32	271	170	66	560	350	100	848	530
33	280	175	67	568	355	200	1696	1060
34	288	180	68	577	360	300	2544	1590

m.	33.d.	57 d.	m.	33.d.	57 d.	m.	33.d.	57. d.
1	8	5	35	294	191	69	579	376
2	17	11	36	302	196	70	587	381
3	25	16	37	311	202	71	596	386
4	34	22	38	319	207	72	604	392
5	42	27	39	327	212	73	612	397
6	50	33	40	335	218	74	621	403
7	59	38	41	344	223	75	629	408
8	67	44	42	352	229	76	637	414
9	76	49	43	361	234	77	646	419
10	84	54	44	369	240	78	654	425
11	92	60	45	377	245	79	663	430
12	101	65	46	386	251	80	671	436
13	109	71	47	394	256	81	679	441
14	117	76	48	403	262	82	688	446
15	126	82	49	411	267	83	696	452
16	134	87	50	419	272	84	705	457
17	143	93	51	428	278	85	713	462
18	151	98	52	436	283	86	721	468
19	159	104	53	445	288	87	730	473
20	168	109	54	453	294	88	738	479
21	176	114	55	461	300	89	747	484
22	185	120	56	470	305	90	755	490
23	193	125	57	478	310	91	763	495
24	201	131	58	487	316	92	772	501
25	210	136	59	495	321	93	780	506
26	218	142	60	503	327	94	789	512
27	227	147	61	512	332	95	797	517
28	235	153	62	520	338	96	805	522
29	243	158	63	529	343	97	814	528
30	252	163	64	537	348	98	822	533
31	260	169	65	545	354	99	831	539
32	269	174	66	554	355	100	839	545
33	277	180	67	562	365	200	1677	1089
34	285	185	68	571	370	300	2516	1634



n.	24 d.	56 d.	m.	24 d.	56 d.	m.	24 d.	56 d.
1	8	6	35	290	196	69	572	386
2	17	11	36	298	201	70	580	391
3	25	17	37	307	207	71	588	397
4	33	22	38	315	212	72	597	403
5	41	28	39	323	218	73	605	408
6	50	34	40	332	224	74	613	414
7	58	39	41	340	229	75	622	419
8	66	45	42	348	235	76	630	425
9	75	50	43	356	240	77	638	431
10	83	56	44	365	246	78	647	436
11	91	61	45	373	251	79	655	442
12	99	67	46	381	257	80	663	447
13	108	73	47	390	263	81	671	453
14	116	78	48	398	268	82	680	458
15	124	84	49	406	274	83	688	464
16	133	89	50	414	280	84	696	470
17	141	95	51	423	285	85	705	475
18	149	101	52	431	291	86	713	481
19	158	106	53	439	296	87	721	486
20	166	112	54	448	302	88	729	492
21	174	117	55	456	307	89	738	498
22	182	123	56	464	313	90	746	503
23	191	129	57	473	319	91	754	509
24	199	134	58	481	324	92	763	514
25	207	140	59	489	330	93	771	520
26	216	145	60	497	335	94	779	526
27	224	151	61	506	341	95	788	531
28	232	157	62	514	346	96	796	537
29	240	162	63	522	352	97	804	542
30	249	168	64	530	358	98	812	548
31	257	173	65	539	363	99	821	554
32	265	179	66	547	369	100	829	559
33	274	184	67	555	374	200	1658	1118
34	282	190	68	564	380	300	2487	1678

m.	35.d	55.d.	m.	35.d.	55.d.	m.	35.d.	55.d.
1	8	6	35	286	301	69	565	396
2	1	11	36	295	206	70	573	402
3	25	17	37	303	212	71	582	407
4	33	23	38	311	218	72	590	413
5	41	29	39	319	224	73	598	419
6	49	34	40	328	229	74	606	425
7	57	40	41	336	235	75	615	430
8	66	46	42	344	241	76	623	436
9	74	52	43	352	246	77	631	442
10	82	57	44	360	252	78	639	448
11	90	63	45	368	258	79	647	453
12	98	69	46	377	264	80	655	459
13	106	75	47	385	270	81	664	465
14	115	80	48	393	275	82	672	470
15	123	86	49	401	281	83	680	476
16	131	92	50	410	287	84	688	482
17	139	98	51	418	292	85	696	488
18	147	103	52	426	298	86	705	493
19	156	109	53	434	304	87	713	499
20	164	115	54	442	310	88	721	505
21	172	120	55	451	315	89	729	511
22	180	126	56	459	321	90	737	516
23	188	132	57	467	327	91	746	522
24	196	138	58	475	333	92	754	528
25	205	143	59	483	338	93	762	534
26	213	149	60	491	344	94	770	539
27	221	155	61	500	350	95	778	545
28	229	161	62	508	356	96	786	551
29	237	166	63	516	361	97	795	556
30	246	172	64	524	367	98	803	562
31	254	178	65	533	373	99	811	568
32	262	184	66	541	379	100	819	574
33	270	189	67	549	384	200	1638	1147
34	278	195	68	557	390	300	2458	1721



m.	36 d.	54 d.	m.	36 d.	54 d.	m.	36 d.	54 d.
1	8	6	35	284	206	69	558	406
2	16	12	36	291	211	70	566	411
3	24	18	37	299	217	71	574	417
4	32	23	38	307	223	72	582	423
5	40	29	39	315	229	73	590	429
6	48	35	40	324	235	74	599	435
7	57	41	41	332	241	75	607	441
8	65	47	42	340	247	76	615	447
9	72	53	43	348	253	77	623	453
10	81	59	44	356	258	78	631	458
11	89	65	45	364	264	79	639	464
12	97	70	46	372	270	80	647	470
13	05	76	47	380	276	81	655	476
14	113	82	48	388	282	82	663	482
15	121	88	49	396	288	83	671	488
16	129	94	50	404	294	84	680	494
17	138	100	51	413	300	85	688	500
18	146	106	52	421	306	86	696	506
19	154	112	53	429	311	87	704	511
20	162	118	54	437	317	88	712	517
21	170	123	55	445	323	89	720	523
22	178	129	56	453	329	90	728	529
23	186	135	57	461	335	91	736	535
24	194	141	58	469	341	92	744	541
25	202	147	59	477	347	93	752	547
26	210	153	60	485	353	94	760	553
27	218	159	61	493	358	95	768	558
28	226	164	62	502	364	96	777	564
29	235	170	63	510	370	97	785	570
30	243	176	64	518	376	98	793	576
31	251	182	65	526	382	99	801	582
32	259	188	66	534	388	100	809	588
33	267	194	67	542	394	200	1618	1176
34	275	200	68	550	400	300	2427	1763

m.	37.d.	53.d.	m.	37.d.	53.d.	m.	37.d.	53.d.
1	8	6	35	279	210	69	551	415
2	16	12	36	287	216	70	559	421
3	24	18	37	295	222	71	567	427
4	32	24	38	303	228	72	575	433
5	40	30	39	311	234	73	583	439
6	48	36	40	319	241	74	591	445
7	56	42	41	327	247	75	599	451
8	64	48	42	335	253	76	607	457
9	72	54	43	343	259	77	615	463
10	80	60	44	351	265	78	623	469
11	88	66	45	359	271	79	631	475
12	96	72	46	367	277	80	639	481
13	104	78	47	375	283	81	647	487
14	112	84	48	383	289	82	655	493
15	120	90	49	391	295	83	663	500
16	128	96	50	399	301	84	671	506
17	136	102	51	407	307	85	679	512
18	144	108	52	415	313	86	687	518
19	152	114	53	423	319	87	695	524
20	160	120	54	431	325	88	703	530
21	168	126	55	439	331	89	711	536
22	176	132	56	447	337	90	719	542
23	184	138	57	455	343	91	727	548
24	192	144	58	463	349	92	735	554
25	200	150	59	471	355	93	743	560
26	208	156	60	479	361	94	751	566
27	216	162	61	487	367	95	759	572
28	224	168	62	495	373	96	767	578
29	232	174	63	503	379	97	775	584
30	240	180	64	511	385	98	783	590
31	248	186	65	519	391	99	791	596
32	256	192	66	527	397	100	799	602
33	264	198	67	535	403	200	1597	1204
34	271	204	68	543	409	300	2396	1805



m.	38.d.	52.d.	m.	38.d.	52.d.	m.	38.d.	52.d.
1	8	6	35	276	216	69	544	425
2	16	12	36	284	222	70	552	431
3	24	18	37	292	228	71	559	437
4	31	25	38	299	234	72	567	443
5	39	31	39	307	240	73	575	450
6	47	37	40	315	246	74	583	456
7	55	43	41	323	252	75	591	462
8	63	49	42	331	259	76	599	468
9	71	55	43	339	265	77	607	474
10	79	62	44	347	271	78	615	480
11	87	68	45	355	277	79	623	486
12	95	74	46	362	283	80	630	493
13	102	80	47	370	289	81	638	499
14	110	86	48	378	296	82	646	505
15	118	92	49	386	302	83	654	511
16	126	99	50	394	308	84	662	517
17	134	105	51	402	314	85	670	523
18	142	111	52	410	320	86	678	530
19	150	117	53	418	326	87	686	536
20	158	123	54	426	332	88	693	542
21	166	129	55	433	339	89	701	548
22	173	136	56	441	345	90	709	554
23	181	142	57	449	351	91	717	560
24	189	148	58	457	357	92	725	566
25	197	154	59	465	363	93	733	573
26	205	160	60	473	369	94	741	579
27	213	166	61	481	376	95	749	585
28	221	172	62	489	382	96	751	596
29	229	179	63	496	388	97	764	597
30	236	185	64	504	394	98	772	603
31	244	191	65	512	400	99	780	610
32	252	197	66	520	406	100	788	616
33	260	203	67	528	412	200	1576	1231
34	268	209	68	536	419	300	2364	1847

m.	39.d.	51.d.	m.	39.d.	51.d.	min.	39.d.	51.d.
1	8	6	35	272	220	69	536	434
2	16	13	36	280	226	70	544	440
3	23	19	37	287	233	71	552	447
4	31	25	38	295	239	72	559	453
5	39	31	39	303	245	73	567	459
6	47	38	40	311	252	74	575	466
7	54	44	41	318	258	75	583	472
8	62	50	42	326	264	76	591	478
9	70	57	43	334	271	77	598	485
10	78	63	44	342	277	78	606	491
11	85	69	45	350	283	79	614	497
12	93	75	46	357	289	80	622	503
13	101	82	47	365	296	81	629	510
14	109	88	48	373	302	82	637	516
15	116	94	49	381	308	83	645	522
16	124	101	50	388	315	84	653	529
17	132	107	51	396	321	85	661	535
18	140	113	52	404	327	86	668	541
19	148	119	53	412	334	87	676	547
20	155	126	54	419	340	88	684	554
21	163	132	55	427	346	89	692	560
22	171	138	56	435	352	90	699	566
23	179	145	57	443	359	91	707	573
24	186	151	58	451	365	92	715	579
25	194	157	59	458	371	93	723	585
26	202	164	60	466	378	94	731	591
27	210	170	61	474	384	95	738	598
28	217	176	62	482	390	96	746	604
29	225	182	63	489	396	97	754	610
30	233	189	64	497	403	98	762	617
31	241	195	65	505	409	99	769	623
32	249	201	66	513	415	100	777	629
33	256	208	67	521	422	200	1554	1259
34	264	214	68	528	428	300	2331	1888



m	40.d.	50 d	m.	40.d.	50 .	min.	40.d.	50.d
1	8	6	35	268	225	69	529	443
2	15	13	36	276	231	70	536	450
3	23	19	37	283	238	71	544	456
4	31	26	38	291	244	72	552	463
5	38	32	39	299	251	73	559	469
6	46	38	40	306	257	74	567	476
7	54	45	41	314	263	75	574	482
8	61	51	42	322	270	76	582	485
9	69	58	43	329	276	77	590	495
10	77	64	44	337	283	78	597	501
11	84	71	45	345	289	79	605	508
12	92	77	46	352	296	80	613	514
13	100	83	47	360	302	81	620	521
14	107	90	48	368	309	82	628	527
15	115	96	49	375	315	83	636	533
16	123	103	50	383	321	84	642	540
17	130	109	51	391	328	85	651	546
18	138	116	52	398	334	86	659	553
19	146	122	53	406	341	87	666	559
20	153	129	54	414	347	88	674	566
21	161	135	55	421	353	89	682	572
22	169	141	56	429	360	90	689	579
23	176	148	57	437	366	91	697	585
24	184	154	58	444	373	92	705	591
25	192	161	59	452	379	93	712	598
26	199	167	60	460	386	94	720	604
27	207	173	61	467	392	95	727	611
28	214	180	62	475	399	96	735	617
29	222	186	63	483	405	97	743	623
30	230	193	64	490	411	98	751	630
31	237	199	65	498	418	99	758	636
32	245	206	66	506	424	100	766	643
33	253	212	67	513	431	200	1532	1286
34	260	219	68	521	437	300	2298	1928

m.	41.d.	49.d.	m.	41.d.	49.d.	m.	41.d.	49.d.
1	8	7	35	264	229	69	521	452
2	15	13	36	272	236	70	528	459
3	23	20	37	279	243	71	536	466
4	30	26	38	287	249	72	543	472
5	38	33	39	294	256	73	551	478
6	45	39	40	302	262	74	558	485
7	53	46	41	309	269	75	566	492
8	60	52	42	317	275	76	574	498
9	68	59	43	324	282	77	581	505
10	75	66	44	332	289	78	589	512
11	83	72	45	339	295	79	596	518
12	91	79	46	347	302	80	604	525
13	98	85	47	354	308	81	611	531
14	106	92	48	362	315	82	619	538
15	113	98	49	369	321	83	626	544
16	121	105	50	377	328	84	634	551
17	128	112	51	385	334	85	641	557
18	136	118	52	392	341	86	649	564
19	143	125	53	400	348	87	656	571
20	151	131	54	407	354	88	664	577
21	159	138	55	415	361	89	671	584
22	166	144	56	422	367	90	679	590
23	174	151	57	430	374	91	687	597
24	181	157	58	438	380	92	694	603
25	189	164	59	445	387	93	702	610
26	196	171	60	453	394	94	709	616
27	204	177	61	460	400	95	717	623
28	211	184	62	468	407	96	724	629
29	219	190	63	475	413	97	732	636
30	226	197	64	483	420	98	739	643
31	234	203	65	490	426	99	747	649
32	241	210	66	498	433	100	755	656
33	249	216	67	506	439	200	1509	1312
34	257	223	68	513	446	300	2264	1968



m.	42. d.	48 d.	m.	42. d.	48 d.	m.	42. d.	48. d.
1	7	7	35	262	234	69	513	462
2	15	13	36	267	241	70	520	468
3	22	20	37	275	247	71	527	475
4	30	27	38	282	254	72	535	482
5	37	33	39	290	261	73	542	488
6	44	40	40	297	268	74	550	495
7	52	47	41	304	274	75	557	502
8	59	53	42	312	281	76	564	509
9	67	60	43	319	287	77	572	515
10	74	67	44	327	294	78	579	522
11	82	73	45	334	301	79	587	529
12	89	80	46	342	308	80	594	535
13	97	87	47	349	314	81	602	542
14	104	93	48	357	321	82	609	549
15	111	100	49	364	328	83	617	555
16	119	107	50	372	335	84	624	562
17	126	113	51	379	341	85	632	569
18	134	120	52	386	348	86	639	575
19	141	127	53	394	354	87	647	582
20	149	134	54	401	361	88	654	589
21	156	140	55	409	368	89	661	595
22	163	147	56	416	375	90	669	602
23	171	154	57	423	381	91	676	609
24	178	160	58	431	388	92	684	615
25	186	167	59	438	394	93	691	622
26	193	174	60	446	401	94	699	629
27	201	180	61	453	408	95	706	635
28	208	187	62	461	415	96	713	642
29	215	194	63	468	421	97	721	649
30	223	201	64	475	428	98	728	655
31	230	207	65	483	435	99	736	662
32	238	214	66	490	442	100	743	669
33	245	221	67	498	448	200	1486	1338
34	253	227	68	505	455	300	2229	2007

m.	43 d.	47 d.	m.	43 d.	47 d.	m.	43 d.	47 d.
1	7	7	35	256	239	69	505	470
2	15	14	36	263	245	70	512	477
3	22	20	37	270	252	71	519	484
4	29	27	38	278	259	72	526	491
5	36	34	39	285	266	73	534	498
6	44	41	40	292	273	74	541	505
7	51	48	41	300	280	75	548	511
8	58	54	42	307	186	76	556	518
9	66	61	43	314	293	77	563	525
10	73	68	44	322	300	78	570	532
11	80	75	45	329	307	79	578	539
12	88	82	46	336	314	80	585	546
13	95	89	47	344	320	81	592	552
14	102	95	48	351	327	82	600	559
15	110	102	49	358	334	83	607	566
16	117	109	50	366	341	84	614	573
17	124	116	51	373	348	85	622	580
18	132	123	52	380	355	86	629	587
19	139	130	53	388	361	87	636	593
20	146	136	54	395	368	88	643	600
21	153	143	55	402	375	89	651	607
22	161	150	56	409	382	90	658	614
23	168	157	57	417	389	91	665	621
24	175	164	58	424	395	92	673	627
25	183	170	59	431	402	93	680	634
26	190	177	60	439	409	94	687	641
27	197	184	61	446	416	95	695	648
28	205	191	62	453	423	96	702	655
29	212	198	63	461	430	97	709	661
30	219	205	64	468	436	98	717	668
31	227	211	65	475	443	99	724	675
32	234	218	66	483	450	100	731	682
33	241	225	67	490	457	200	1463	1364
34	248	232	68	497	464	300	2194	2046



m	44.d.	46.d.	m	44.d.	46.d.	min.	44.d.	46.d.
1	7	7	35	252	243	69	496	479
2	14	14	36	259	250	70	503	486
3	22	21	37	266	257	71	511	493
4	29	28	38	273	264	72	518	500
5	36	35	39	280	271	73	525	507
6	43	42	40	288	278	74	532	514
7	50	49	41	295	285	75	539	521
8	58	56	42	302	292	76	547	528
9	65	62	43	309	299	77	554	535
10	72	69	44	316	306	78	561	542
11	79	76	45	324	313	79	568	549
12	86	83	46	331	320	80	575	556
13	93	90	47	338	327	81	583	563
14	101	97	48	345	334	82	590	570
15	108	104	49	352	340	83	597	577
16	115	111	50	360	347	84	604	584
17	122	118	51	367	354	85	611	590
18	129	125	52	374	361	86	619	597
19	137	132	53	381	368	87	626	604
20	144	139	54	388	375	88	633	611
21	151	146	55	396	382	89	640	618
22	158	153	56	403	389	90	647	625
23	165	160	57	410	396	91	655	632
24	173	167	58	417	403	92	662	639
25	180	174	59	424	410	93	669	646
26	187	181	60	432	417	94	676	653
27	194	188	61	439	424	95	683	660
28	201	195	62	446	431	96	690	667
29	209	201	63	453	438	97	698	674
30	216	208	64	460	445	98	705	681
31	223	215	65	468	452	99	712	688
32	230	222	66	475	458	100	619	695
33	237	229	67	482	465	200	1439	1389
34	245	236	68	489	472	300	2158	2084

m.	45 d.	45 d.	m.	45 d.	45 d.	m.	45 d.	45 d.
1	7	7	35	247	247	69	488	488
2	14	14	36	254	254	70	495	495
3	21	21	37	261	261	71	502	502
4	28	28	38	268	268	72	509	509
5	35	35	39	275	275	73	516	516
6	42	42	40	283	283	74	523	523
7	49	49	41	290	290	75	530	530
8	56	56	42	297	297	76	537	537
9	64	64	43	304	304	77	544	544
10	71	71	44	311	311	78	551	551
11	78	78	45	318	318	79	558	558
12	85	85	46	325	325	80	566	566
13	92	92	47	332	332	81	573	573
14	99	99	48	339	339	82	580	580
15	106	106	49	346	346	83	587	587
16	113	113	50	353	353	84	594	594
17	120	120	51	360	360	85	601	601
18	127	127	52	367	367	86	608	608
19	134	134	53	375	375	87	615	615
20	141	141	54	382	382	88	622	622
21	148	148	55	389	389	89	629	629
22	155	155	56	396	396	90	636	636
23	163	163	57	403	403	91	643	643
24	170	170	58	410	410	92	650	650
25	177	177	59	417	417	93	657	657
26	184	184	60	424	424	94	665	665
27	191	191	61	431	431	95	672	672
28	198	198	62	438	438	96	678	678
29	205	205	63	445	445	97	686	686
30	212	212	64	452	452	98	693	693
31	219	219	65	459	459	99	700	700
32	226	226	66	466	466	100	707	707
33	233	233	67	474	474	200	1414	1414
34	240	240	68	481	481	300	2121	2121





Now for the forme of setting downe a reckoning although hee which is accustomed to keepe it in this manner, may happily by use and practise discerne how to order it in a better way than I can presently prescribe or thinke upon, because hee hath occasion often to consider it in every particular: yet in the meane time I conceive it will be fit to have a booke in folio that is, two leaves to a sheete of paper, and to keepe the left side of your booke void, that you may write therein all such occurrences as you shall thinke requisite. As namely, the Winds and the points of the Compasse upon which your shippe lyes, and what allowance you make for leeward way when you sayle by a winde, the number of glassees or houres, and how many knots or miles in each houre, also the Latitudes which you finde by observation of the Meridian altitude of the Starres, and what else you shall thinke remarkable. But before all this, the title of the voyage in these or the like words.

*The Iournall of our voyage intended by Gods assistance from S. I. in the Latitude of 32 deg. 25' to the coast of England, &c.*

The right hand pages, or the right side of your booke throughout may by lines bee divided into twelve Columns, as in the example following doth appeare. In the first colume may be expressed the *day*, in the second, *moneth*, (or at least once in the top of the page,) likewise in the same second colume being large enough, may bee set downe the *Latitudes* which you finde by the *Meridian altitudes* of the Sunne, at such times as you make observation. In the third colume, the course (the *Leeward* way, if there be any leeing allowed.) In the fourth, the

O

*variation*



*variation of the Needle.* In the fifth (having made allowance for the variation) set downe the Angle of your *Rumbe* with the *Meridian*. In the sixth colūme set downe the *distance* in miles runne upon that *Rumbe*. In the seventh, eighth, ninth, and tenth colūms, the *Northing* or *Southing*: *Easting* or *Westing*, thereto answering; as you shall finde it by your *Table*. In the eleventh, your *Latitudes* by dead reckoning. And lastly, in the twelfth colūme you may at such times as you thinke fittest, set downe your *Longitude* from the place from which you first departed, or the difference of *Longitude* from place to place.

For an example, wee may frame a reckoning between the two places before mentioned, namely from *Summers Islands* to the *Lizard*, whose distance in their *rumbe* wee have before supposed to bee 3299 miles (as some *Charts* make it, and consequently their difference of *Longitude* 70 deg. I would not bee understood as if I affirmed it to be so much, for I suppose it is lesse. I was there indeed about 20 yeares past and surveyed it, and then kept a reckoning both outwards and homewards, but I have lost those reckonings long since, and have forgotten what they were, and in this case it matters not, for whether the supposition be neare the truth or not, it serves sufficiently to exemplifie the rule, that being the end for which it is used. But if their distance bee 3299, such miles as containe onely 1000 paces in a mile, the same being reckoned in such miles as we have before mentioned, namely in such whereof 60 make a degree of a great circle, which as we finde containe 6120 feet in a mile: their distance will bee little more than 2695 miles; and consequently, the difference of *Longitude* little more than  $55\frac{1}{2}$  degrees.

Let us therefore suppose the difference of longitude between

betweene these two places to bee 55 degrees, and their Latitudes to bee the same as before, namely of the one 32 degrees 25 min. and of the other 50 degrees. And let the courses, distances and other observations from Summers Islands to the Lizard be such as heere follow.

O 2

Day



da.	and Lat. by observation	couric	varya.	deg. from the Merid.	dist. in mil.	North	So.	East.	West	La. by dead R.	Longit.
20	February	N E	8 deg	ne 48 d.	miles 78	522		579		d. 33.17	
21	Latitude 34 d. 25'	N E	8 deg	ne 48 d.	100	669		743		34.24	
21	34 d. 25'			Summe is		1191		1322		34.24	02.28
22		e n e	8 de.	ne 54 de.	100	588		809		35.56	
		$\frac{1}{2}$ po: n	west.		56	329		453			
23	Latitude 37 d. 46'	e n e	8 de.	ne 54 de.	100	588		809		37.40	
		$\frac{1}{2}$ no:	west.		78	458		631			
24	Latitude 39 d. 36'	e n e	8 de.	ne 54 de.	100	588		809		39.28	
		$\frac{1}{2}$ no.	west.		84	494		679			
				Summe is		3045		14190			
				The correction by observation is	80			110		108	
24	39 d. 36'					3125		4300		39.36	11.36
25	February	e n e	8 deg	ne 59 $\frac{1}{2}$	100	507		861		41.05	
			west		76	385		655			
26		e n e	8 deg	ne 59 $\frac{1}{2}$	100	507		861		42.37	
			west		80	412		586			
27	Latitude 43 de. 55'	e n e	7 $\frac{1}{2}$ de	ne 60 de.	100	500		866		44.09	
			west		84	420		728			
				Summe is		2731		4657			
				Correction		140		245		14	
27	Lat. 43.55					2591		4412		43.55	21.28
28	February	e n e	6 deg	ne 67 deg	100	391		921		44.54	
		$\frac{1}{2}$ e	west		51	199		469			
29		e n e	5 deg	ne 68 deg	100	375		927		46.02	
		$\frac{1}{2}$ e	west		81	304		751			
1	March	e n e	4 deg	ne 69 deg	100	358		934		47.02	
		$\frac{1}{2}$ e	west		66	237		616			
2	La. 48.04	e n e	2 deg	ne 71 deg	100	326		946		48.00	
		$\frac{1}{2}$ e	west		78	254		737			
2	La. 48.04			Summe is		2444		6301		48.00	36.38

igit.

da.	Lat. by ob- servat on.	course	vary- ance.	Deg. from the Merid.	dist. in miles.	North	Sou.	East.	west.	Lat. by dead R.	Longit
3	March	e n e	0. deg	1 e 73 de	100	192		956		48.44	
		$\frac{1}{2}$ e	west		52	152		497			
4		e n e	2 deg	1 e 75 de.	100	259		966		49.28	
		$\frac{1}{2}$ e	East.		68	176		657			
5	Latitude 49.58.d.	e n e	3 deg	1 e 76 de.	98	237		951		49.52	
		$\frac{1}{2}$ e	East.								
5	L. 49.58										
Summe is						1116		14027		149.52	46.52

28

36

5	8 Houres	n by e	4 deg	n e 21	18	168		64		50.09	
		$\frac{1}{2}$ e	East								
6		s by e	4 deg	s e 07	34		337	41		49.35	
			East								
6	16 howr.	n by e	4 deg	n e 15	36	348		93		50.10	
			East								
7		s e	4 deg	s e 52	20		123	158		49.58	
		by e	East								
8	Latitude 50 de. 04	East	4 deg	s e 86	96		67	958		49.51	
			East								
	The cur- rent setting be estima.	e n e		n e 67 $\frac{1}{2}$	60	230		554		50.14	
Summe is						1219		11868			
Correct.							100			10'	
8	L. 50.04					1119		11868		50.04	51.43

28

9		E $\frac{1}{2}$	6 deg	se 89 $\frac{1}{2}$ d.	70	60	700	49.58
		po. n	East					
10		E $\frac{1}{2}$	6 deg	se 89 $\frac{1}{2}$ d.	52	41	520	49.54
		po. n	East					
10	March			Summe is		1101	1220	49.54 54.53
	Here the							
	Liyard	N by E.		13				
	beares							

38



This first entrance in this journall ( which is the 20 day of February ) is thus to be understood ; namely, that from the time of setting saile ( which wee suppose to be the 19 of February ) till the 20 day at noone, the ship lies away and makes her way good upon the Northeast and by East point of the Compasse ; but the variation being 8 deg. to the Westwards ( as in the fourth collume appeares ) the rumbe upon which she hath runne is from the North to the Eastwards onely 48 deg. as is expressed in the fift collume ( it is indeed  $48\frac{1}{4}$  deg. but the  $\frac{1}{4}$  deg. we omit, as for the other circumstances not to be regarded ) upon this rumbe shee runnes 78 miles, as in the sixt collume appeares, and answerable thereto I finde in the table before going, the Northing to be  $52\frac{1}{2}$  miles, and the Easting  $57\frac{1}{2}$  miles, as here in the seventh and ninth collumes is exprest by these numbers 522 and 579 ( for the first figure towards the right hand signifieth the tenth parts of a mile, the rest miles. ) Hence then the Northing being 52 miles, if that be added to the Latitude from which it is reckoned, namely 32 deg. 25 min. it makes the latitude here to be 33 degrees 17 minutes as in the eleventh collume appeares. In like sort the second entrance being the 21 of February, sheweth that from the 20 day at noone to the 21 she made her way good upon Northeast and be East point of the Compasse, but the variation being 8 deg. Westerly, the angle of the rumbe with the true Meridian was from the North to the Eastwards 48 deg. and so sayling 100 miles, the northing is  $69\frac{1}{2}$  miles, and the easting  $74\frac{1}{2}$  miles ; so that the Latitude now is 34 deg. 24 min. and the like is to be understood of all the rest.

Touching the Longitude expressed in the last collume, although a reckoning may be kept and set downe without it, yet it is of very good use, and how to convert the easting

ing or westing, (that is the miles expressed in the East and West columes of your journall) into deg. and min. of Longitude, we will shew afterwards, as also how you may easily correct your course, and give the true course or rumbe allowing the variation.

But first to proceed with this journall, observing the Meridian altitude of the Sunne upon the 23 and 24 of February, I findethat my Latitude upon the 24 day is 39 deg. 36 min. whereas by dead reckoning it is but 39 deg. 28 min. so the difference is 8 more northerly; but being well assured of the Latitude found by observation, I correct the dead reckoning thereby, which may be done by the rule of proportion saying,

As the summe of the north colume	3125.	co. ar.	6,50515
To the summe of the east colume	4300		3,63347
So the foresaid encrease northerly	80		1,90309
To the encrease easterly	110		2,04171

that is 11 miles: for the first place towards the right hand is onely for the tenth parts of a mile.

The same may also sufficiently be found without the rule of proportion by the foregoing table, onely for looking there under the degree upon which I have sayled, namely, under 54 deg. for 8 miles or 80 tenths of a mile, though I finde not the same exactly, yet I finde one which is neere it, namely 82, and against it in the next collaterall colume 113, which is  $11\frac{3}{4}$  miles, (beeing too much by  $\frac{3}{4}$  of a mile, because the other is too much by  $\frac{2}{4}$ ) I adde therefore in the North colume of the journall 8 miles, and in the East colume 11 miles: And so whereas by dead reckoning, the northing was but  $304\frac{1}{4}$  miles, and the easting 419 miles: now having corrected it by observation, the northing is  $312\frac{1}{4}$  miles, and the easting 430 miles.



In like sort upon the 27 day, I should by dead reckoning bee in the Latitude of 44 deg. 09 min. but by a cleare and good observation, I finde my selfe in the Latitude of 43 deg. 55 min. that is not so much northerly by 14 min. therefore to correct it I put in the south colume 14 miles or 140 tenths, and seeing my course was between the North and the East, and that I finde my selfe to bee lesse to the northwards, that is, more to the southwards than my reckoning, therefore in probability I am also lesse to the eastwards, that is more to the westwards than my reckoning; but to finde how much, I looke in the foregoing table for the degree upon which I have sayled, being from the north part of the Meridian to the eastwards 60 deg. and under 60 deg. I looke for 14 miles or 140 tenths, and against it in the colume adjoyning I finde 243 which I set downe in my journall in the west colume; and so subtracting the first from the north colume, the other from the east: I finde that whereas by dead reckoning I should bee to the northwards  $273 \frac{1}{2}$  miles, and to the eastwards  $465 \frac{1}{2}$ . Now having corrected it by observation, I finde that from the 24 day till this time, I have runne more northerly than I was by  $259 \frac{1}{2}$  miles, and more easterly by  $441 \frac{1}{2}$  miles.

But if your course be neare the East or west, it may suffice to correct it in Latitude onely, as in the example of the 8 of March appears; for in that case you cannot correct the longitude but from some further ground.

If there bee any current you may note it as is done in that example following the 8 of March.

Now if you would set downe this reckoning upon the Plaine or Common Sea-chart: First, if you desire to expresse every dayes account, you may begin for the 20 of February, and make a pricke in your platt that may bee from the place from which you sett sayle

to

to the Northwards  $52\frac{2}{7}$  miles, and to the Eastwards  $57\frac{2}{7}$ ; and so will this point be distant from the place of your setting Sayle 78 miles, Northeast and almost a quarter of a Point Easterly: then for the 21 day you make another Prick which may be from the forme to the Northwards  $66\frac{2}{7}$  miles, and to the Eastwards  $74\frac{3}{7}$  miles, and so you may proceed with the rest: And thus you shall have a Prick on the Plot for every day more exactly set downe then could be done after the ordinary way by Course and Distance, or Course and Latitude, especially because in lining the Plot, there are not, nor cannot conveniently be drawne any more then the 32 Points of the *Compass*; to wit, not halfe Points, quarters, or single Degrees.

But if you desire not to set downe every dayes reckoning (which is not necessary to be done) you may set down every of the Summes as they are corrected by observation after the selfe-same manner.

Or you may adde together all those summes, and so the summe totall of the North Colume, will be 1049 miles, and of the East Colume 2345 miles; therefore in the *Meridian* of the place from which you depart, you may set down to the Northwards of that place 1049 miles, which will fall in the Latitude of 49 Degrees 54 min. almost, and from thence in that Parallel set downe directly to the Eastwards 2345 miles, and there make a prick for the place where the Ship then is the tenth of *March*, and so is all this reckoning set downe at once.

If you keep reckoning according to *Mercator*, it will be requisite sometimes to sum up your reckonings past, namely so often as you make any notable alteration in your Course: And so this reckoning or any other may be set down almost as easily on *Mercators Chart*, the difference is, that here you must often alter your *Scale*, because the deg. of Latit. on this Chart are not equall



but grow greater and greater towards the Poles. Now then the distance of two places is to be measured by that part of the *Meridian* which is intercepted between the Latitudes of those two places; Or if both places lye in one and the same *Latitude*, their Distance is measured by a Degree or other lesser quantity, taken about that *Latitude*; namely halfe above, and halfe beneath.

Wherefore if you would make a Prick or Traverse-point in *Mercators Chart* answering to your Reckoning for the first day, namely untill the 20 of *February* at noone, it appears by your journall that Prick must be to the *Northwards* of the place from which you departed 52 $\frac{1}{2}$  Miles, and to the Eastwards 57 $\frac{1}{2}$  miles. Now instead of the *North* or *South* Columes, you may more conveniently use the last Colume but one, shewing in what *Latitude* every account doth fall; and so it appears that the Prick for the 20 of *Februarie* must be in the *Latitude* of 33 deg. 17 min. Therefore in the *Meridian* of the *Summer-Ilands* from which you departed, make a prick in the *Latitude* of 33 degr. 17 minutes, and from that Prick set down to the *Eastwards* in the same *Latitude* 57 $\frac{1}{2}$  miles, and where it ends is the Traverse-point answering to the 20 of *February*: the like may be done for the 21 day, and so for all the rest. This 58 miles may bee taken in the *Meridian* from the *Latitude* of 32 deg. 22 min. to the *Latitude* of 33 deg. 20 minutes, or otherwise you may take the halfe of it which is 29 miles about the middle between both *Latitudes*, and double it.

But it is sufficient to set downe the summes of every two or three dayes accounts, or so often as there is any notable difference in your Course; thus if you would make a Prick in the Chart, answering to the 21 of *February* being the first Summe; I see by the journall that it must bee in the *Latitude* of

34 degrees 24 minutes, and to the *Eastwards* of the place from which I departed 132  $\frac{1}{2}$  miles. Therefore in the Meridian of the place from which I departed, I make a Prick in the Latitude of 34 degrees 24 minutes, and from that prick I set in the same Latitude to the *Eastwards* 132  $\frac{1}{2}$  miles, and where it ends is the Traverse-point answering to the 21 of *February*, being the first summe. This 132 miles may be taken in the Meridian within or a little without the two Latitudes as before, namely from 32 degrees 20 minutes, to 34 degrees 32 minutes.

In like sort, if you would make a Prick for the second Summe being the 24 of *February*, it there appears that it must be in the Latitude of 39 degrees 36 minutes, and to the *Eastwards* of the Traverse-point last before made 430 miles; therefore in the *Meridian* of that Traverse-point I make a Prick in the Latitude of 39 deg. 36 minutes, and from that Prick I set to the *Eastwards* in the same Latitude 430 miles, and where that ends, is the traverse-point answering to the 24 day, and the like is to be understood of all the rest.

Now this 430 miles may be taken severall wayes; for first if I take one Degree about the middle of that part of the *Meridian* which is intercepted between the Latitudes of the two places (as from 36 deg. 30 minutes, to 37 deg. 30 minutes) and that degree seven times taken is 420 miles, then about the middle namely 37 deg. I take 10 minutes more, and so I have 430 miles.

In like manner, you may take 2 deg. or 120 miles, to measure it thereby, which may be taken from 36 deg. to 38 deg. and the residue about 37 degrees, as before, &c.

Or you may take the halfe of 430 miles, namely 215 miles, which is 3. deg. 55. min. which must be taken as before



before about the middle of that part of the *Meridian* which is intercepted betweene the two Latitudes, and that doubled is 430 miles, to be set to the Eastwards as before.

And thus may this or any other reckoning be set downe without knowledge of the Longitudes, but more aptly and exactly by some Longitudes knowne, for then shall you have in the two last Columns the substance and principall scope of your reckoning; namely, the Latitudes and Longitudes of all places as you Sayle, which may more easily and exactly be expressed upon this Chart, then the Easterly or Westerly Distances; Therefore how this also may bee done we will shew, but first something touching the *Compassse* and the *Variation* thereof, which ought not to be neglected in a reckoning.

#### CHAP. X.

### *Of the Variation of the Compassse,*

*and how to rectifie a Course by the Variation knowne.*



Amongst all the Mysteries which God hath of late yeares discovered to the World for the furtherance of *Navigation*, there is none more necessary nor yet more admirable then that propertie of the *Needle* touched with the *Loadstone*, whereby in the vast Ocean where all Land-Markes faile, yea even in the darkest Nights and closest weather, when neyther Sunne nor Starres are to bee seene: the Mariner (as it were by a Messenger sent from

from Heaven) is taught which way to direct his Ship, yea as it were accompanied with a guide towards his desired Port.

For the *Needle* touched, besides other strange properties hath this, to point out in all quarters of the world, the North and South parts of the Horizon, and so having a Card thereto fitted with Rumbes and Degrees, it sheweth all Points of the Compasse, and Degrees of the Horizon.

Yet very seldome exactly of it selfe without some further Art and Industry of him that useth it; for though in some places it swarves not yet in most parts of the World, the North and South points of the Needle, have some Variation from the true North and South Points of the Horizon to the Eastwards or to the Westwards, which how to discover in kind and quantity, we have shewed here-to-fore.

vide Lib: 2. 1  
pag. 27. 8  
+ pag. 28.

It may be thought, (and some men otherwise learned before this property was fully discovered, have said) that this should be some blemish and imperfection in a Stone so precious: But it is so farre from being an imperfection, that it makes it so much the more precious. Yet (as I have said) not without the industry of him that useth it. He that is negligent or unskillfull to observe it, especially in long Voyages and various Courses, may be led into many dangers by it, because he frames not his mind to the Rule but the Rule to his minde, imagining it to bee what it is not, and hence I suppose, sprang that Custom of placing the *Needle* or *Wyers* a Point or halfe a point to the Eastwards of the North-point of the Card, thinking by this meanes to shunne the labour of observing the Variation, which indeed they might if the Variation were the same in all places and at all times, but because it is not, this doth often increase the Errour.



But he that diligently observes the variation, findes (as I say) no prejudice in it, onely it requires dayly, or once in two or three dayes halfe an houres worke, and this labour it doth abundantly recompence; for by this meanes he knowes at the present how to direct his Course, and for the future, by those notes which he keepes of the *Variations* and *Latitudes* by him observed, he knowes (comming that way againe) when he drawes neare to any of those places where such observations were made, and so falls the more certainly with any place intended.

There is further discovered of late, a motion or alteration in the Variation of the Needle, and this is scarce yet certainly discovered. But comparing the variations which were observed about 50 yeeres past, with the present Variations: it appeares they are lesse *Easterly* and more *Westerly* by 6 or 7 Degrees, then they were at that time. For whereas the Variation hath formerly beene observed neare *London* to be  $11\frac{1}{4}$  Degrees to the Eastwards, it doth now scarce exceed 4 Degrees. And there is the like alteration (as I have heard by some Mariners) in other parts of the World; Which we now leave to the further discovery of time and industry, and come to shew how to rectifie a course by the Variation knowne.

*The Point of the Compasse upon which you Sayle,  
and the Variation of the Needle knowne  
to finde the Rumb or Degree upon  
which the Ship hath made  
her way.*

**I**T is best that the Needle or Wyars be placed directly under the *Flowre-de-luce*, or *North* and *South* points of the *Card*, and so in the Rules following, we pre-

presuppose them to be. Now then it is to be understood that the *Needle* having *Variation* (as for the most part it hath) the *Ship* doth not make her way upō that *Rumbe* or *Point* of the *Compass* which she seemes to saile upon, but either more to the right hand or to the left, according as the *Variation* is towards the right hand, or towards the left, & that so much towards the one side or towards the other, as that *Variation* is: We speake not here of *Leeward-way*, but of the *Variation* onely. Therefore for the solution of this *Problem*, you must know how much the *Variation* is, and which way; and how this may be done, wee have briefly shewed upon the 12 Case of *Right-angled Sphericall Triangles*, and the 11 of *Oblique*: Which knowne, you may finde the *Angle* of the *Rumbe* or *Line* of your *Ships* way with the *Meridian*: being the thing in this *Problem* required.

† vide pag: 27. 828.  
Lib: 2.

For the effecting whereof, we will set downe two wayes; the one by the *Pen* alone, the other *Instrumentally*. If you doe it by the *Pen* alone, although it be not hard to finde what *Angle* every point or halfe point makes with the *Meridian*; yet for your further ease herein, I have expressed the same in the *Table* following, the quarters of *Points* I have omitted, because the *Steerage* upon a quarter of a point is very uncertaine, (the points being undivided as usually they are) for a man by his eye is able to guesse very nearely which is the middle betweene two points, but he cannot guesse so nearly which is the fourth part. Yet if you desire any quarter, you may adde to the next before going almost 3 Degrees, namely 2 degrees 49 minutes.

A Table



*A Table of the Angles of every Point and halfe Point of the Compasse with the Meridian.*

	North.	South.	deg. min.	North.	South.
			00. 00.		
$\frac{1}{2}$			05. 37.		
1	N by E.	S by W.	11. 15.	N by W.	S by E.
$1\frac{1}{2}$			16. 52.		
2	N N E.	S S W.	22. 30.	N N W.	S S E.
$2\frac{1}{2}$			28. 07.		
3	NE by N	SW by S	33. 45.	Nw by N	SE by S.
$3\frac{1}{2}$			39. 22.		
4	N E.	S W.	45. 00.	N W.	S E.
$4\frac{1}{2}$			50. 37.		
5	NE by E	SW by W	56. 15.	Nw by W	SE by E
$5\frac{1}{2}$			61. 52.		
6	E N E.	W S W.	67. 30.	W N W.	E S E.
$6\frac{1}{2}$			73. 07.		
7	E by N.	W by S.	78. 45.	W by N.	E by S.
$7\frac{1}{2}$			84. 22.		
8	East.	West.	90. 00.	West.	East.
	Addc East vary			Addc West vary	
	Subtract West.			Subtract East.	

Now then by the Magneticall Rumbe or Point of the Compasse and Variation given: to finde the true Rumbe, you are to observe these two Rules following.

1. If the Rumbe and the Variation be both the same way from the Meridian (namely both to the right hand, or both to the left) addc them together, and that summe is the true Rumbe from that part of the Meridian.

Yet

Yet if that summe exceed 90-degrees, subtract it from 180 degrees, the remayner is the Rumb, from the opposite part of the Meridian.

2 If the one be towards the right hand, the other towards the left; subtract the variation from the Rumb, and the remayner is the true rumb.

Yet if the rumb be the smaller number, subtract it from the Variation, and the remayner is the true rumb the other way.

These Rules we shall endeavour to illustrate by examples following.

But first for distinctions sake we say, the rumbes or degrees from the North towards the East, are towards the right hand, and so from the South towards the West; but from the North to the Westwards, on the left hand, and so from the South Eastwards: For a mans face beeing towards the North the East is on his right hand, and the West on his left: &c.

In like sort for the Variation of the Compasse, if it have Easterly variation; that is, if the Needle and flowre-de-luce of the Card stand to the Eastwards of the North, we say that variation is towards the right hand, for not onely the North point but all the other points of the Compasse direct a course more towards the right hand then they would doe, if there were no Variation. And so if it haue Westerly variation; that is, if the Needle and Flowre-de-luce stand to the Westwards of the true North point of the Horizon, we say that variation is towards the left hand; forasmuch as not onely the North point, but all the other points of the Compasse, stand more towards the left hand then they would doe, if there were no Variation, this beeing premised we come to giue Examples of the two Rules beforegoing.

Q

1 Let



1 Let the Magneticall Rumb or point of the Compasse be North-East, and the Variation 10 degrees to the Eastwards: I demand the true Rumb.

Heere the Rumb and Variation are both one wayes: that is, both towards the right hand; therefore,

To the magnet. Rumb being N Easterly, 45 deg. 00 m.  
 Adde the Variation Easterly ——— 10 deg. 00 m.  
 the summe is the true Rumb N Easterly, 55 deg. 00 m.

2 Admit a Ship saile vpon the North point of the Compasse, and that the variation be 10 degrees to the Eastwards: how doth shee make her way.

The magneticall Rumb is North, that is 00 deg. 00 m.  
 To which adding the Easterly variation, 10 deg. 00 m.  
 The sum is the angle from the North  $\frac{1}{2}$  10 deg. 00 m.  
 part of the Meridian to the Eastwards

Which is almost North by East, and so hath the Ship made her way.

3 Let the point of the compasse be East  $\frac{1}{2}$  point Northerly, that is from the North to the Eastwards 7  $\frac{1}{2}$  points, which is 84 degrees 22 min. and the variation as before 10 degrees to the Eastwards: I demand the true Rumb?

To the magneticall Rumb being N E, 84 deg. 22 m.  
 Adde the Easterly variation ——— 10 deg. 00 m.  
 The summe is the angle from the North, 94 deg. 22 m.  
 Which subtracted from ——— 180 deg. 00 m.  
 There rests the true Run be S Easterly, 85 deg. 38 m.

4 Example. Let the course by the Compasse be West and by South, that is 7 points from the South to the Westwards, or 78 deg. 45 min. and let the variation be as before 10 degrees to the Eastwards: what is the true Rumb?

To

To the magneticall Rumb *S Westerly*, 78 deg. 45 m.  
 Adde the Easterly Variation ——— 10 deg. 00 m.  
 The summe is the true Rumb *S Westerly*, 88 deg. 45 m.

You may conceive that the *Rumb* and *Variation* are heere both one way, namely both from the *Meridian* towards the right hand; For the *Variation* of the *North* point is, from the *North* towards the *East*, and consequently of the *South* point from the *South* towards the *West*, both towards the right hand of the *Meridian* as the *Rumb* is.

5 Example. Let the Course by the *Compass* be *West*, that is, from the *South* to the *Westwards* 8. Points, or 90 Degrees, and let the *Variation* be as before 10 degrees to the *Eastwards*: I would know the true Course or Rumb?

To the magneticall Rumb *South-West*, 90 deg. 00 m.  
 Adde the Variation *Easterly*, ——— 10 deg. 00 m.  
 The summe is the angle with *South* } 100 deg. 00 m.  
 part of the *Meridian*, ——— }  
 Which subtracted from ——— 180 deg. 00 m.  
 There rests the true Rumb *N West*, 80 deg. 00 m.

Let the Course by the *Compass* be *West*, that is, from the *North* to the *Westwards* 8 points or 90 degrees, and let the *Variation* be 10 degrees to the *Westwards*: I demand the true Rumb?

To the magneticall Rumb *N West*, 90 deg. 00 m.  
 Adde the Variation *Westerly*, ——— 10 deg. 00 m.  
 The summe is ——— 100 deg. 00 m.  
 Which subtracted from ——— 180 deg. 00 m.  
 There remains the true rumb *S West*, 80 deg. 00 m.



*Object.* The magneticall Rumbe being here West 90 degrees, why should it not aswell be counted from the South, as from the North.

*Answ.* It may be counted from either, for as it is counted heere from the North to the Westwards it falls under the first Rule, because the Variation is the same way: but if it be reckoned from the South to the Westwards, it falls under the second Rule, whereof we now come to giue some Examples, supposing these already giuen sufficient to illustrate the first Rule.

7 *Example.* Let the point of the Compasse be *NW*, and the Variation 10 deg. Easterly: I demand the true Rumbe.

From the magneticall rumbe *NW*: — 22 deg. 30 m.  
Subtract the Easterly Variation — 10 deg. 00 m.  
The remayner is the true Rumbe *NW*: 12 deg. 30 m.

8 *Example.* Let the point of the Compasse be *N*, and the Variation Easterly 10 deg. What is the true Rumbe.

From the Easterly Variation — 10 deg. 00 m.  
Subtract the magneticall Rumbe, *N*: 00 deg. 00 m.  
The remayner is the true Rumbe, the other way,  
namely — — — — — *NE*: 10 deg. 00 m.

*Object.* The magneticall Rumbe may aswell be named North Easterly, 00 deg. 00 min.

*Answ.* It may, but then it is subject to the first Rule, as in the second Example.

9 *Example.* Let the course by the Compasse be West, that is, from the North to the Westwards 8. points or 90 degrees, and let the Variation be as before 10 degrees to the Eastwards: what is the true Rumbe?

From

From the magneticall Rumbe *NW*: — 90 deg. 00 m.  
Subtract the Easterly *Variation*, — 10 deg. 00 m.  
There rests the true Rumbe *NW*: — 80 deg. 00 m.

Heere the magneticall Rumbe might aswell haue beene South Westerly 90 deg. and so it had fallen vnder the first Rule, as in the first *Example*.

10 *Example*. Let the course by the Compasse be West; that is, from the South to the Westwards 8. points or 90 degrees, and let the *Variation* be 10 deg. to the Westwards: I demand the true Rumbe?

From the magneticall Rumbe *SW*: -- 90 deg. 00 m.  
Subtract the Westerly *Variation* — 10 deg. 00 m.  
Theremayner is the true Rumbe *SW*: 80 deg. 00 m.

If the Rumbe heere had beene reckoned from the North as in the first *Example*, it had fallen vnder the first Rule.

And this may suffice for the illustration of the two former Rules, in the solution of this *Probleme*.

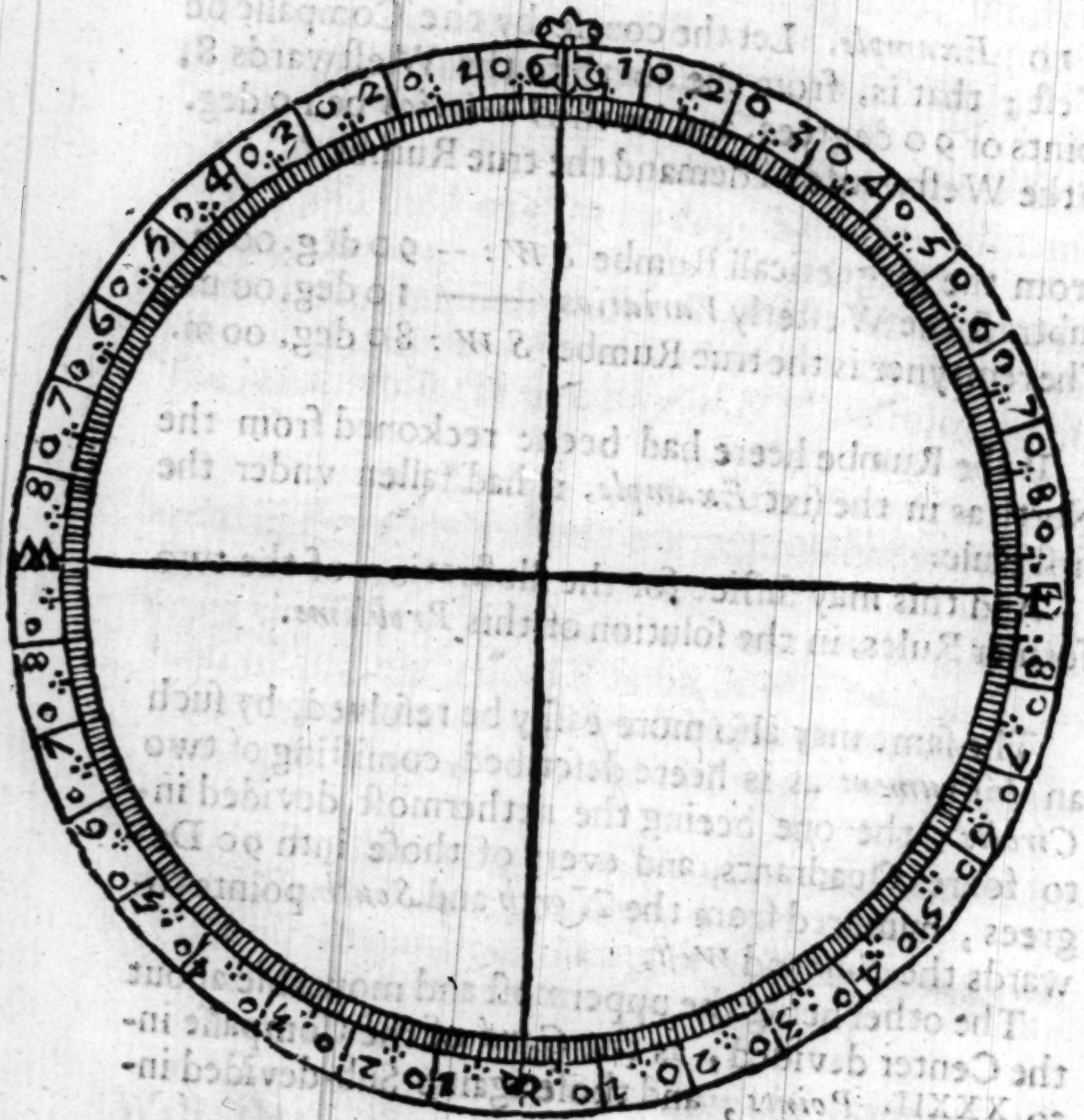
The same may also more easily be resolved, by such an *Instrument* as is heere described, consisting of two *Circles*, the one beeing the nethermost devided into foure Quadrants, and every of those into 90 Degrees, numbred from the *North* and *South* points towards the *East* and *West*.

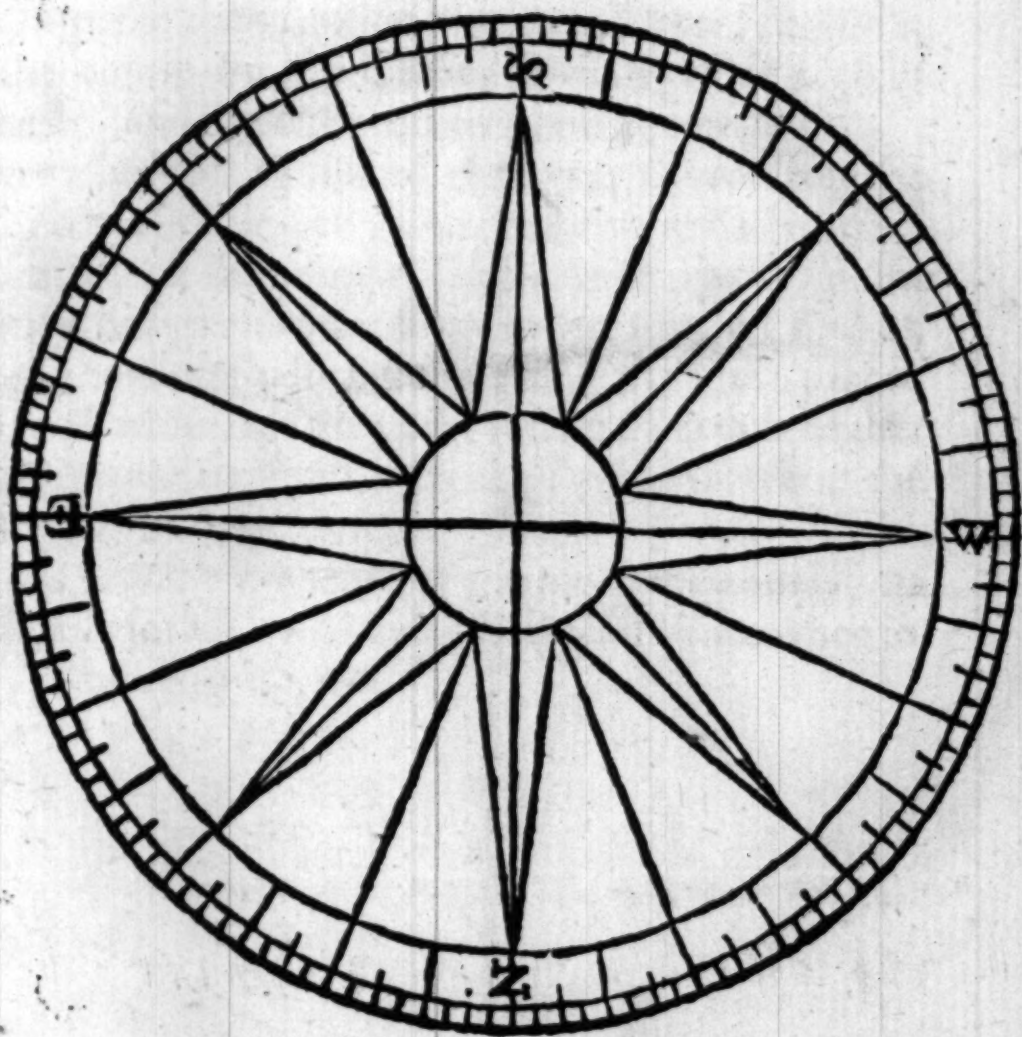
The other being the uppermost and moveable about the Center devided, as the *Card* of the Compasse into XXXII. *Points*, and those againe Sub-devided into halfes, or quarters.

By this you may readily find the true Rumbe for any course and *Variation* giuen.

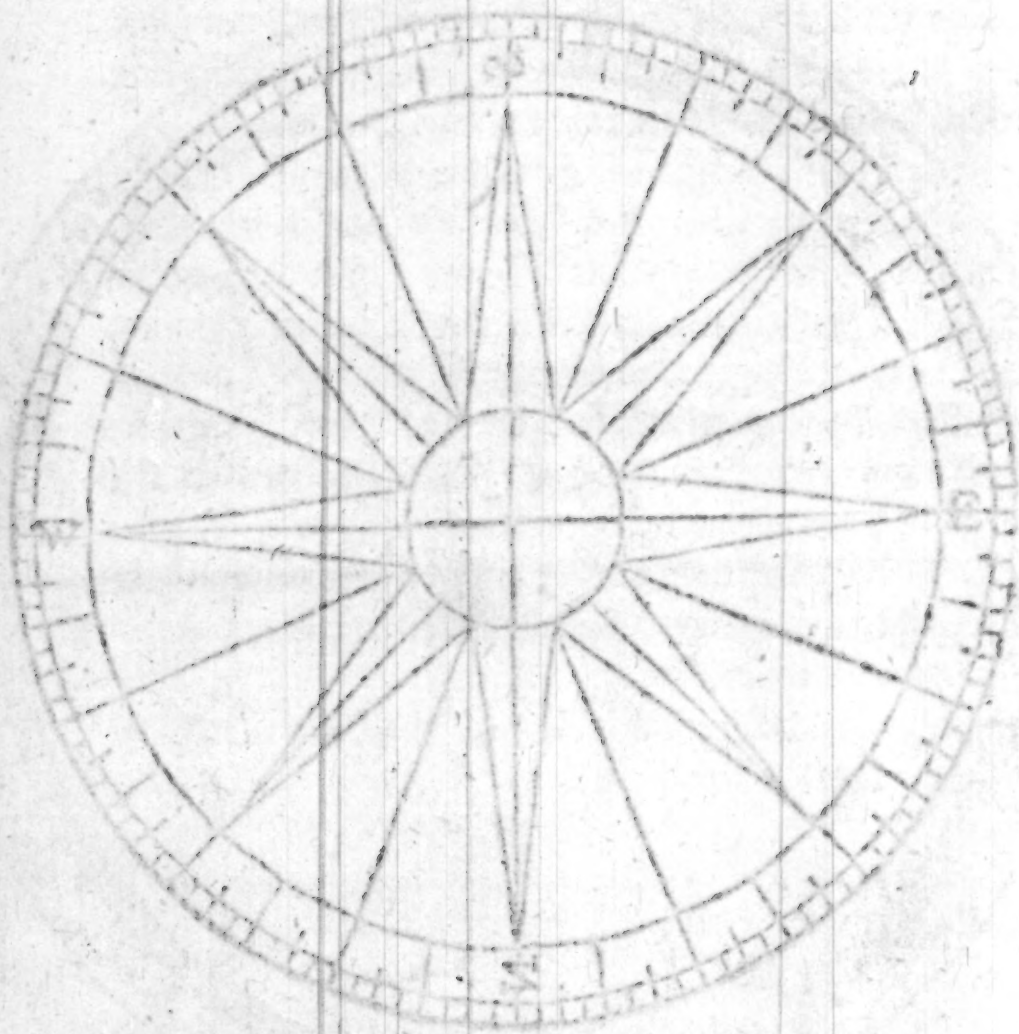


## The Instrument.









For if you turne the North point of the upper circle, from the North point of the lower, so many degrees, and the same way that the variation is, and then looke in the same upper circle, for the magneticall course or point of the Compasse proposed, you shall finde right under it in the nether Circle, what number of deg. the same is distant from the North or South points of the true Meridian towards the East or West, which is the true rumbe here required.

As, suppose the variation to bee 10 degrees Easterly, and the course by the Compasse East, halfe a point Northerly, and there be required the true rumbe?

I turne the North point of the upper Circle from the North point of the lower 10 degrees to the Eastwards; and then I look in the upper Circle, for east halfe a point northerly, & right under it in the nether Circle I find 85 deg. and about one halfe, numbred from the South part of the Meridian towards the East; therefore I conclude that the true *Rumbe* required, is from the South towards the East  $85\frac{1}{2}$  degrees and something more.

By this *Instrument* also (if you use the pen onely, as wee have before shewed) you shall readily see when to adde, and when to subtract.

R

C H A P.



## CHAP. XI.

To keepe a reckoning of your Longitude, and so to set  
downe a reckoning by longitude and  
latitude owely.

**I**N the Example before given of a Journall,  
wee have in the twelwe and last Columnne, ex-  
pressed in such places as it seemed most requi-  
site, the Longitudes: wee come now to shew  
how the same may be knowne, and first;

*By the Rumbe, and Latitudes given: to finde  
the difference of Longitude.*

As Radius is in Proportion  
To the Tangent of the Rumbe:  
So is the difference of Latitude in Meridionall parts  
To the difference of Longitude in minutes.

As let the Rumbe be North-easterly 48. degrees, and  
suppose a Shippe to runne upon this Rumbe, from the  
Latitude of 32 degrees 25' into the Latitude of 34 de-  
grees 24' there is required the difference of Lon-  
gitude.

Heere

The meridionall parts answering to	34 deg. 24'	2200
The meridionall parts for	32      25	2058
The difference of Latitude in such parts is		<u>142.</u>

Say then

As Radius is in proportion		
To the Tangent of the Rumbe	t 48 deg. 00'.	10,0456
So differ. of Latitude in mer. parts	142	<u>2,1523</u>
To the difference of longit. in min.	158	2,1979.
		These

These minutes converted into degrees, are 2 deg. 38' which is the difference of Longitude required, as the same is expressed in the Journall against the 21 of February.

And thus sayling upon one & the same rumbe, you may finde the difference of Longitude, and so often as you alter your rumbe, so often working by the same rule, you shall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may also finde the difference of longitude neare enough at one operation for many severall rumbes and distances; provided that those rumbes differ not much one from another. As in the former Journall from the 27. of February till the second of March, I sayle by severall rumbes and distances from the Latitude of 43 deg. 55. into the Latitude of 48 deg. if you would finde the difference of longitude hereto answerable, at one operation, it may be done by this rule:

As the difference of Longitude in miles,  
Is to the departure from the Meridian in miles,  
So is the difference of Latitude in Meridionall parts  
To the difference of Longitude in minutes.

As in that example, the difference of Latitude for all those courses, as in the North collumne appeares, is 2444.

The departure from the Meridian, as there in the East collumne appeares, is 6301.	
The meridionall parts for the Latitude of	43 deg. 55' are 2939
The meridionall parts for the Latitude of	48 deg. 0' are 3292
The difference of Latitude in meridionall parts is	353

Say then

R 2

As



As the difference of Latitude	2444	co. ar.	6,6119
To the departure from the merid.	6301		3,7994
So the difference of Latitude in			
meridionall parts	353		<u>2,5478</u>
To the difference of longit. in mi.	910		2,9591

Which reduced into degrees is	15 deg. 10'
And added to the former Longitude	21 deg. 28'
Gives the present Longitude	36 deg. 38' for
the second of March.	

The like may be done for the account from the second of March to the fifth of the same, &c.

But if your courses and distances runne, be all neare to one and the same parallel or Latitude (as in this Journall they are from the fifth of March to the eighth, and from the eighth to the tenth) then it is sufficient to find what Longitude in that parallel is answerable to the miles of Easting, or Westing, or departure from the Meridian by this rule.

As the sine complement of the Latitude of that parallel  
Is in proportion to Radius,  
So is the number of miles in that parallel  
To the difference of Longitude in minutes.

As from the fifth of March to the eighth, the Latitude was neare 50 deg. the Easterly distance 186  $\frac{1}{2}$  miles, therefore for the difference of Longitude, say;

As Sine compl. the Latitude	sc 50 deg. 00'	,1919
To Radius,		
So is the departure from the meridian	186. 8	<u>3,2714</u>
To the difference of Longitude	290. 6	3.4633

Thus it appears the difference of Longitude is almost  
291

291 minutes, which is 4 deg. 51', and this added to the longitude upon the fift of March, namely to 46 deg. 52', the Summe is 51 deg. 43', the Longitude upon the eighth of March, the like might bee done for the tenth of March.

And though this last rule bee then fittest to bee used when your course is neare East and West, or your difference of Latitude little: yet it may also bee used at other times in stead of the two former, without any great error, if you take the middle degree of Latitude, or somewhat more: as in the former example.

The Latitude upon the 27 of February is	43 deg. 55'
The Latitude upon the 2 of March is	48 deg. 00'
The midle Latitude, or somewhat more is	46 deg. 10'

Say then,  
 As sine compl, the Latitude                      sc 46 deg. 10', 1595  
 To Radius,  
 So the Easting or departure from the  
     meridian,    630. 1. 3,7994  
 To the difference of Longitude                      909. 7. 3,9589  
 Which is almost 910 min, or 15 deg. 10' as before.

And thus you may in the twelke and last collume of your Journall, set downe your Longitude so often as you thinke is requisite; and so in the two last collumes, you shall have the substance and principall scope of your reckoning, namely your Latitudes, & Longitudes, which whensoever you desire to set downe in *Mercators* Chart, or in the polar Chart, or in any other graduated with degrees of Longitude, and Latitude you may readily doe it.

As if I would set downe the summe of the foresaid Journall from the 19 of February, to the tenth of March: I finde against the tenth of March the Latitude to bee 49



49 deg. 54', and the difference of Longitude 54 deg. 53'; therefore in the Latitude of 49 deg. 54', I draw an occult parallel, and reckoning from Summers Islands towards the East 54 deg. 53', I draw by that Longitude an occult meridian, the intersection of this meridian with the foresaid parallel is the traverse point, or the point representing the place of the shippe, and the like is to bee understood of any other.

This forme of keeping and expressing a reckoning, is, as I conceive, most apt and agreeable ( of all others that I have seene or thought upon ) to all sorts of Charts or Mapps, and to the Globe it selfe, and to all the kindes or wayes of sayling, that are or may bee used. Wee will here adde some other propositions which may sometimes be of good and necessary use in it.

*The Rumbe and difference of Latitude given: to finde by the table, the distance in the Rumbe, and the departure from the Meridian thereto answerable, &c.*

**H**OW to finde the Northing or Southing, that is, the distance in Latitude, as also the Easting or Westing, that is, the distance in longitude or departure from the Meridian of any rumbe, for any distance runne upon it, we have before shewed, the like operation is in these propositions following, namely :

2. *The Rumbe and distance in Latitude given: to finde the distance in the Rumbe, and the Easting or Westing.*
3. *The distance, and difference in Latitude given: to finde the departure from the Meridian, and the Rumbe.*
4. *The difference in Latitude, and departure from the Meridian*

- Meridian given: to finde the course and distance.*  
 5. *The course and departure from the Meridian given: to  
 finde the difference of Latitude and distance.*  
 6. *The distance and departure from the Meridian given:  
 to finde the course and difference of Latitude.*

So that with the first before handled, here are six propositions, and in every of them two things required, and so they become twelve. Wee will not stand to give examples of them all, but onely of those which are most usefull, the rest may by them be conceived.

And first to finde the Easting or Westing of any rumbe for any difference of Latitude.

Admit a shippe runne North-easterly 60 deg. (that is N. E. by E. and almost halfe a point Easterly) till shee have altered the Latitude 42': how much is shee departed from the Meridian?

I runne down the collume under 60 deg. till I finde 42 miles, or 420 tenths, and against it in the adiacent collumne I finde 728 tenthes, that is almost 73 miles, which is the departure from the Meridian to the Eastwards.

If you would also have the distance upon the rumbe, it is right against these numbers in the colume of distances, being in this example 84 miles.

## 2. Example.

But admit shee runne North-easterly 60 deg. till shee alter her Latitude 1 deg. 32': What is the easterly distance.

This 1 deg. 32' is 92 miles or 920 tenthes, for which if I looke in the collume under 60 deg. I find no number so great, but the greatest number there, is 500, which

sub-



subtracted from 920, there  
remaines 420, therefore  
in that collume under 60 deg.

100	500	866
84	420	728
184	920	1594

I looke for these two numbers, namely 500 and 420, and against the first in the adiacent collumne I finde 866 and against the second 728, which I set against them as above appeareth, and so adding them, I finde for this difference of Latitude, the departure from the Meridian to be 159  $\frac{4}{5}$  miles.

If further you desire the distance runne upon this rumbe, you have it in the collumne of distances, right against the same numbers, as in the example above appeareth where being added it amounts to 184 miles.

*The Distance and difference in Latitude given :  
to finde the rumbe and departure from  
the Meridian.*

**A**Dmit a Shippe runne upon some rumbe, betweene the North and the East 84 miles, and then have altered her Latitude 42 minutes: the question is, upon what rumbe hath shee runne, and how many miles is shee to the Eastward in Longitude?

I runne crosse the table towards the right hand, looking in every first collume, of distances for 84 till I finde against it in one of the adiacent collumes 420, at the toppe of which collume over 420, there is 60 deg. shewing the rumbe to be North Easterly 60 deg. also against 420 in the adiacent collume I find 728, which sheweth the distance to the Eastwards to be almost 73 miles.

*2. Example.*

But if the distance, runne be 184 miles, and the difference

rence of Latitude 1 deg. 32'. and there bee required the rumbe and distance to the Eastwards?

Because the collumne of distances extends but to 100 miles, and the distance here given is 184 miles, you may take the halfe therof, which is 92 miles, and likewise the halfe of 1 deg. 32', which is, 46 miles or 460 tenthes; and then looke a before where you finde 460 against 92, for there in the top of the collumne you shall finde the rumbe, which in this example is 60 deg. shewing that the rumbe is from the North-easterly 60 deg. and in the adjacent collumne against 92 and 460, you shall finde 797 which doubled (because it is for the halfe) is 1594, shewing that the departure from the Meridian to the Eastwards, is  $159\frac{4}{5}$  miles.

These and the rest may also bee performed by the Doctrine of *Plaine triangles*, as wee have formerly shewed.

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CHAP. XII.

*Certaine Problemes touching Currents.*



Although the time bee already expired which I assigned for this worke, and mine owne more urgent occasions call me away: yet seeing it is necessary in Navigations to take notice of Currents, and to make a competent allowance for them: I will briefly set downe certaine Problemes, such as I have sometimes thought upon, whereby a man may the better conceive and iudge of that allowance, the rather for that I know not any that hath handled it.

First then it is to be conceived, that a shippe or other vessell sayling or rowing where there is a Current, hath a

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compound motion arising of two different principles, namely, of the current, and shippes way; so that here are three motions to be considered; namely, two simple, and the third compounded of them. The first simple motion is that of the current, whereby it moveth, and is apt to move other things that are in it, the same way: The second, of the ship or boate as it moveth by wind or oares, or is apt to bee moved, if there were no current: The third, compounded of them, is the line of the shippes true motion. The first we call, the way or motion of the current: the second, the way or simple motion of the shippe: the third, her compound or true way. The two simple motions being either of them according to right lines and uniforme: (as in the problemes following, we suppose them to be) the third also, which is composed of them, is a right line: For whether the ship sayle directly opposite against the current, or directly with it the same way, or whether the one crosse the other at right angles or at oblique: yet still either motion being direct and uniforme, they both together beget a right lined uniforme motion, because the one retaineth to the other, one and the same proportion in every point: And according to these grounds we proceed in the problems following, to determine the proportions of every of these motions, and the angles which they make one with another.

1. *Admit a Current runne East 3 miles an houre, and that a shippe under sayle runne West directly against it, 6 miles an houre in her simple motion; What is her true or compound motion?*

From the shippes simple motion	6 miles,
Subtract the current	3 miles,
The remainder is the ships true motion	3 miles,
So the shippes true way is to the westwards 3 miles an houre:	2. <i>Ad-</i>

2. Admit a Current runne West 6 miles an houre,  
and that a shippe under sayle, runne directly  
against it, five miles an houre by the logg :  
What is the ships compound motion, and which  
way?

From the current being the greater 6 miles,  
Substract the ships simple motion 5 miles,  
There remaines the ships true motion — 1 mile,  
Which — 1 mile shewes that the ship by her com-  
pound motion faller a sterne, that is, moves to the West-  
wards 1 mile an houre.

In the experimentall practice of the two former pro-  
blemes, it may seeme that a ship or boat so ordered,  
hath also a motion to the right hand or to the left, but  
this comes to passe, because it is hard, and in a manner  
impossible to stemme a tide or streame so exactly, but  
that the ship will swarve (or yaw as they say) either to  
the one side or to the other.

3. Admit a Current runne East 3 miles an houre,  
and that the ship also runne East 3 miles an  
houre by the logge : what is the ships true  
motion?

To the ships simple motion 3 miles,  
Add the current 3 miles,  
The summe is the ships true motion 6 miles,  
So the ships compound or true way is East 6 miles an  
houre.

4. Admit a current runne East 2 miles an houre,  
and the ship South 6 miles an houre ; what is the  
ships true motion, and which way?



In handling of any Art, to avoyd circumlocution there are used termes or words of Art, serving to expresse briefly the things handled. And forasmuch as this subject hath not beene formerly handled, nor the principles or grounds thereof laid (so farre as I know) we will adde a few such termes as may seeme most necessary, expressing here what we meane by them.

Let the line AB runne from A to the Southwards, and BD from B to the Eastwards, and let AB be in proportion to BD as 6 to 2 or 3 to 1.

Then doth AB represent the line of the ships simple motion, BD the motion of the current, and AD the compound motion of the ship.

And DAB is the angle contained between the line of the ships simple motion, and the line of her compound or true motion, which for brevities sake wee will henceforth call *the angle of deflection*.

Also ADB is the angle contained between the line of the ships compound motion, and the set or drift of the current which we will call *the angle of reflection*.

Lastly, ABD is the angle contained between the line of the ships simple motion, and the set of the current, which we will call *the angle of incidence*.

Then for the rumbe, the proportion is thus:

As the simple motion	AB	6 miles co. ar.	9,2219
Isto the current	BD	2 miles	0,3011
So is Radius			

To the tangent of deflection tDAB 18 deg. 26' 9,5230

So the rumbe upon which the ship makes her way good is South 18 deg. 26 Easterly, that is, s s e 4 deg. 4 Southerly.

2. For the ships true way or compound motion,  
 As the sine of the deflection s DAB 18 deg. 26' 0,5000  
 To the current DB 2 miles 0,2011  
 So Radius  
 To the true motion AD 6  $\frac{33}{4}$  0,8011  
 So the ships compound motion is 6  $\frac{33}{4}$  miles hourly,  
 that is 6  $\frac{3}{4}$  miles almost

5. A ship sayles west five dayes together, by the Logg  
 725 miles, but there is a current, all this while  
 setting to the Southwards 1  $\frac{1}{2}$  mile an houre; I  
 demand how she hath sayled, and how farre.

The current setting 1  $\frac{1}{2}$  mile an houre, settis in five  
 dayes 180 miles, therefore  
 As the simple motion AB 725 miles 7,1397  
 Is to the current DB 180 miles 2,2553  
 So is Radius  
 To the tangent of deflection, t DAB 13 deg. 57' 9,3950  
 For the distance  
 As sine compl the deflection sc DAB 13 deg. 57' 0,0130  
 Ist to the simple motion AB 725 min. 2,8603  
 So is Radius  
 To the compound motion AD 747 2,8733  
 So the ships true way is, west Southerly 13 deg 57' or  
 Southwesterly 76 deg 03' 747 miles.

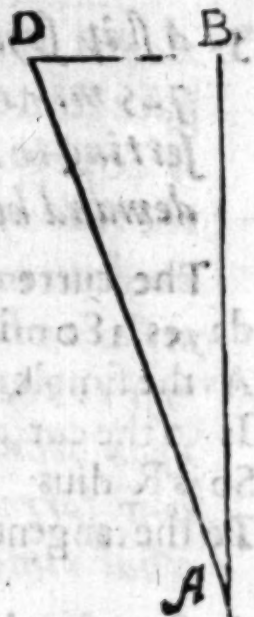
6. A ship sayles West 5 dayes together, by the Logg  
 725 miles, in a current setting to the South-  
 wards, and then finds that he hath altered his La-  
 titude 3 deg. I demand the motion of the current,  
 the true Rumb and true way of the ship.

This question differeth little from the former, for seeing  
 the difference of Latitude is 3 deg the motion of the  
 current is 180 miles: so there is given the ships simple  
 motion, and the motion of the current as before, &c.



7. A ship in 6 houres sayles from a certain cape or head-land, South 30 miles by the logg, in a current setting easterly, and then observing the same cape, he findes that it beares n n w, I demand how fast that current settts, and how farre bee hath sayled.

As let a ship sayle from A towards B. South 30 miles, but by meanes of the current, shee is driven more easterly, namely to D. from whence setting the the cape A. it is found to beare n n w. And seeing the current settts from B. towards D. easterly, therefore the angle of reflection B D A. is 6 points, that is 67 deg. 30'. Here then is demanded the distance A D, and the drift of the current in that time B D.



As the signe of the Angle  
of reflection ———

s B D A 67 deg. 30' ,0344

To the simple motion of  
the ship ———

A B. 30 miles 1,4771

So the sine of the angle  
of deflection ———

s D A B. 22 deg. 30. 9,5736

To the motion of the  
current ———

B D ~~12~~ 12 <sup>16</sup>/<sub>100</sub> 1,0851

And further,

As the sine of the angle  
of reflection ———

s B D A 67 deg. 30' ,0344

To the distance runne by  
the logg ———

A B 30 miles. 1,4771

So is Radius

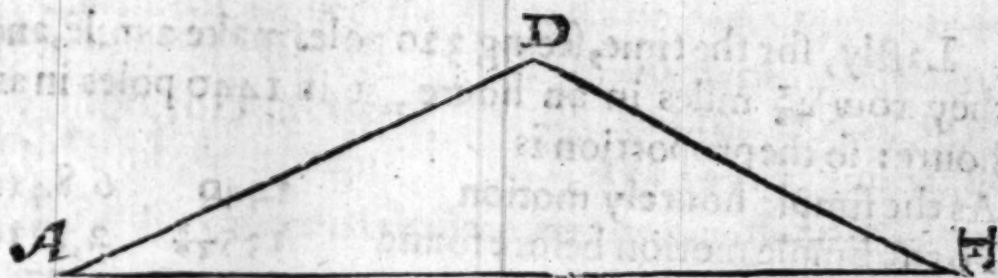
To the compound motion  
of the ship ———

A D 32 <sup>47</sup>/<sub>100</sub> 1,5115  
And

And thus we finde that current to set  $12 \frac{1}{2}$  that is, neare  $12 \frac{1}{2}$  miles in 6 houres, and the distance runne to be  $32 \frac{1}{2}$  miles almost.

That the thing may be better conceived, wee will use two or three examples more familiar and obvious to every mans experience: yet grounded upon the same principles and reasons.

8. Admit that Tulis staires beare from Billingsgate staires sw Southerly; namely South-westerly 40 deg. and be distant 80 poles: and suppose the tide of ebb to runne there Eastwads  $2 \frac{1}{2}$  miles an houre, and that a paire of oares, rowing  $4 \frac{1}{2}$  miles an houre, would goe straight over from the first to the second: how shall they row over, namely upon what degree or point of the Compasse, and how farre shall they row to get thither, and in what time?



Let A represent Billingsgate staires, D Tulis staires, A E the simple motion of the boate, E D the motion of the current: then is A the angle of deflection; E, the angle of incidence; D the angle of reflection 130 deg. or 50 deg.

As



As the simple motion of  
the boat

Is to the motion of the tide

So the sine of reflection

To the sine of deflection

A E  $4\frac{1}{2}$  miles 9,34679

D E  $2\frac{1}{2}$  miles 0,39794

D s 50 deg. 9,88425

A. s 23 deg. 3' 9,62898

Thus then the position from A to D being South-westerly 40 deg. and the angle of deflection A, 23 deg. 03' the position from A towards E is South-westerly 63 deg. 03' that is, ~~W~~s w, Southerly. And so must those Oares row to goe straight over.

Secondly for the distance A E.

From the angle of reflection

Subtract the angle of deflection

And there rests the angle of incidence

D, 50 deg. 00'

A 23 deg. 03'

E 26 deg. 57'

As the sine of incidence

To the true distance

So the sine of reflection

To the simple motion

s, E 26 deg. 57' 0,34370

A D 80 poles 1,90309

s, D 50 deg. 00' 9,88425

A E  $135\frac{1}{2}$  p. 2,13104

Lastly, for the time, seeing 320 poles make a mile, and they row  $4\frac{1}{2}$  miles in an houre, it is 1440 poles in an houre: so the proportion is

As the simple houely motion

To the simple motion before found

So is an houre in minutes, namely

To the time required in minutes

And so long will they be rowing over.

1440 6,8416

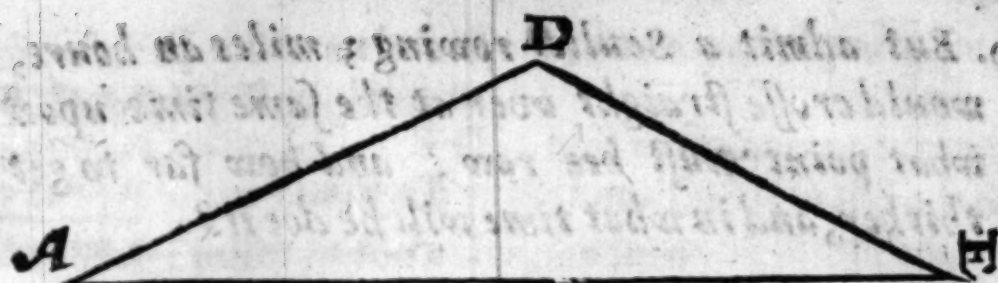
$135\frac{1}{2}$  2,1310

60' 1,7781

$5\frac{5}{8}$  0,7507

9. But suppose they will row harder, to goe a shorter cut; namely, to goe s w by w. how fast must they row to goe straight over, and how far, and in what time?

Then



Then seeing the position from A to D is Southwesterly 40 deg. and s w by w, is Southwesterly 56 deg. 15' therefore the angle of deflection at A is 16 deg. 15', the angle of reflection D as before 50 deg. 00', the angle of incidence E is 33 deg. 45'.

As the sine of deflection A 16 deg. 15' . 55311  
To the motion of the tide DE 2  $\frac{1}{2}$  miles 0,39794  
So the sine of the angle of reflection D 50 deg. 00' 0,88425

To the simple hourly motion of the boat AE 6  $\frac{344}{1000}$  0,83530

And such is the hourly motion of the boat, namely 6  $\frac{344}{1000}$  miles in an houre.

Secondly for the simple motion:

As the sine of incidence E 33 deg. 45' . 25526  
Is to the true distance AD 80 poles 1,90309  
So the sine of reflection D 50 deg. 00' 0,88425  
To the simple motion AE 110  $\frac{1}{10}$  p. 2,04260

Thus it appears they must row 110  $\frac{1}{10}$  poles to get over.

Lastly for the time.

The hourly motion before found 6  $\frac{344}{1000}$  reduced into poles, is 2190  $\frac{1}{10}$ .

As the simple hourly motion 2190 6,65956  
Is in proportion to an houre or 60' 1,77815  
So is the simple motion before found 110  $\frac{1}{10}$  2,04260

To the time required 3  $\frac{22}{100}$  m. 0,48031

And so long will they be rowing over.

T

10. But



10. But admit a Sculler rowing 3 miles an houre, would crosse straight over at the same time, upon what point must hee row, and how far to get thither, and in what time will he doe it?

First for the angle of position.

As the houely motion of  
the boat

AE 3 miles 9,51288

To the sine of reflection

D, s, 50 deg. 9,88425

So is the houely motion  
of the streame

DE 2  $\frac{1}{2}$  min. 0,29794

To the sine of deflection

A, s, 39 d. 40' 9,80507

Now seeing the position for *Billingsgate* to *Tulis* staires, namely from A to D is by supposition to the westwards of the South 40 deg. & the angle of deflection A is here found to bee 39 deg. 40', therefore the position from A to E is from the South to the Westwards 79 deg. 40', which is West and by South, and almost 1 deg. westerly, and so must that Sculler row to goe straight over.

Secondly for the distance AE.

From the angle of reflection

D 50 deg. 00'

Subtracting the angle of  
deflection

A 39 deg. 40'

There remains the angle  
of incidence

E 10 deg. 20'

As the sine of incidence

s E 10 deg. 20' 0,174624

To the true distance

AD 80 poles 1,90309

So is the sine of reflection

s D 50 deg. 00' 9,88425

To the simple motion

AE 34  $\frac{1}{2}$  P. 2,53358

And thus it appears that though the distance of the two places be but 80 poles, yet if according to the question, he row but after 3 miles an houre, and the streame set

set after  $2\frac{1}{2}$  miles an houre, then hee must row  $341\frac{1}{2}$  poles to goe straight over.

Lastly, for the time.

Three miles is 960 poles, say then		
As the simple hourly motion	960	7,01773
To the simple motion before found	$341\frac{1}{2}$	2,53358
So is an houre in minutes, namely	60	1,77815
To the time required in minutes	$21\frac{1}{2}$	1,32946

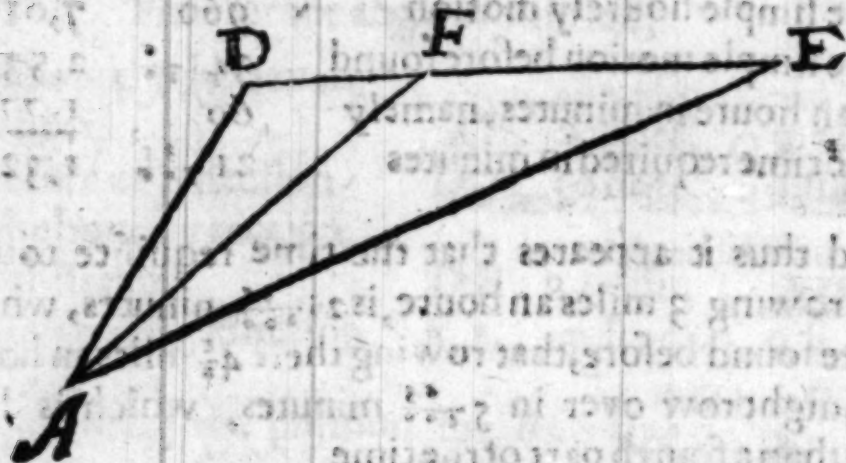
And thus it appeares that the time requisite to row over, rowing 3 miles an houre, is  $21\frac{1}{2}$  minutes, whereas wee found before, that rowing there  $4\frac{1}{2}$  miles an houre, they might row over in  $5\frac{1}{2}$  minutes, which is little more than a fourth part of the time.

There might be other and that great variety of questions of this nature proposed and resolved, many of good use in practise, which the watermen by daily experience without other rules, are able to guesse at something nearely, sufficing for their occasions: my intent in these is especially to explicate the compound motion of a ship or other vessell sayling or rowing where there is a current; which by such familiar examples may seeme more evident. I cannot insitt upon them by reason of mine other occasions, nor spend that time in these here handled, which else I should have done; whence if any defect or mistake should arise, if the reader be pleased to give me friendly notice of it, I shall as thankfully accept it, and reforme it: Wee propose next a question at sea, which let be this.

**II.** *There is a Current at Sea setting East 12 miles in 24 houres a ship sayles in the same from a certaine Port, west So. west 6 dayes, and then returning thence, and sayling NE by N, 3 dayes, falls with the Port from whence he first departed,*



I demand what his dead reckoning was outwards, and what backe againe, and how far these two ports were assunder, and upon what point of the Compasse.



As let the Current set from E towards D, and let the first part be A, the second F, and let the course outward bound be represented by AE, and the course homewards by DA &c.

And forasmuch a DE is an East and West line, and AE w s w, therefore the angle at E is 22 deg. 30' and by the like reason, the angle at D is 123 deg. 45' or 56 deg. 15', and the angle at A 33 deg. 45', and ED being the setting of the current for 9 dayes, is 108 miles.

First then for the dead reckoning outwards, namely AE.

As the sine of the angle at A. s.	33 deg. 45'	525516
To the line	DE 108 miles	2,03342
So is the sine of the angle	D s 56 deg. 15'	9,91085
To the line	AE 161 $\frac{1}{2}$	2,10833

Thus AE his dead reckoning outwards is 161 $\frac{1}{2}$ .

Secondly

*Secondly for A D.*

As the sine of the angle D A E s 33 45 25526  
 Is to the line D E 108 miles 203342  
 So is the sine of the angle D E A s 22 30 958284  
 To the line A D  $74\frac{4}{5}$  miles 187152  
 Which  $74\frac{4}{5}$  miles is his dead reckoning homewards.

*Thirdly for the angle D A F, or D F A.*

The side A D is found  $74\frac{4}{5}$  miles  
 The side D F for 3 dayes is 36 miles  
 The summe of both is  $110\frac{4}{5}$   
 Their difference is  $38\frac{4}{5}$   
 The summe of the angles  
 D A F and D F A 56 deg. 15'  
 The halfe summe is 28 deg. 07'

*The proportion.*

As the summe of the sides  $110\frac{4}{5}$  7, 95703  
 Is to their difference  $38\frac{4}{5}$  1, 58433  
 So is the tangent of 28 deg. 07' 9, 72706  
 To the tangent of 10 deg. 32 9, 26932  
 Which added together, make the angle D F A  
 38 deg. 39'.

And seeing the rumbe from F to D is East, and the angle D F A 38 deg. 39'  $\frac{1}{2}$ , therefore the rumbe from F to A is to the Northwards of the East 38 deg. 39'  $\frac{1}{2}$ , that is N E by E almost halfe halfe a point Northerly, which is the rumbe from the second port to the first.

*Lastly for A F the distance of these two ports.*

As the sine of the angle D F A s 38 deg. 39'  $\frac{1}{2}$  20434  
 To the deadreckoning homewards A D  $74\frac{4}{5}$  miles 187152  
 So is the sine of the angle D s 56 deg. 15' 901985  
 To the distance A F  $99\frac{2}{5}$  miles 199571  
 Thus the true distance of those two ports is 99 miles and somewhat more.



Sundry other questions of like nature might be proposed, which to him that well understandeth these will not be difficult.

These principles a little enlarged may further with a few experiments, be applyed in the discovery of some mysteries in compound motions not yet divulged; though much indeavoured by sundry famous men in severall parts of *Europe*; but these we shall not touch at present.

*12. To find where there is a Current at Sea; also which way it setts, and how fast.*

This may be done by comparing the reckoning outwards, with the reckoning homewards, whereof wee will give an example or two:

As admit a ship sayle from a certaine port, by one or severall rumbes or distances, till she arrive at a second, & there find reckoning by course and distance that she is more Southerly than the port from which shee departed, by 541 miles, and more Westerly by 145 miles: But by his reckoning homewards, when hee arrives againe at the first place, he findes himselfe to the Northwards of the second 541 miles as before, & to the Eastwards 305 miles. Now supposing he were 3 dayes outwards bound, and five dayes homewards bound, I would know which way the Current sets, and how fast? Here because the Easterly distance homewards is greater then the Westerly distance outwards; therefore from the Easterly distance, 305 miles, subtract the Westerly distance, 145 miles, the remainder being 160 miles, is the motion of the Current to the Westwards.

And thus it appeares that that current sets to the Westwards 160 miles in 8 dayes, that is 20 miles a day, or  $\frac{2}{3}$  of a mile every houre.

*2 Example.*

Admit a ship sayle from the Summer Islands, by severall rumbes and distances, till she arrive at *Ca. Codd* in

in New England. Namely, from the East part of the Summer Ilands, (the variation being allowed) first North 20 miles, and then N N W 150 miles; the second day N by W 180 miles: the third day North 90 miles, the fourth day N E 88 miles, and so arrive at *Ca. Codd*,

	North	South	East	West
North 20 miles	20.0			
N N W 150 miles	138.6			57 4
N by W 180 miles	176.5			35 1
North 90 miles	90.0			
N E 88 miles	62.2		62 2	
528 miles	487.3		62 2	92 5
				62 2
				30 3

then by these courses and distances wee may gather by the foregoing Table that *Ca. Codd*, should by this reckoning be to the Northwards 487 miles: and to the Westwards 30 miles, as here appeares.

Now suppose shee saile backe againe from *Ca. Codd* towards the Summer Ilands, the first day S S W 150 miles, the second day S S W 160 miles, the third day S by W 130 miles, the fourth day South 140 miles, the fift day East 110 miles, and so bee come againe to the East part of the Summer Ilands.

These courses and distances make as here appeareth the Summer Ilands to be to the Southwards of *Ca. Codd* 554 miles, and to the Westwards 30 miles.

Therefore



	North	South	East	West
S W 150 miles	—	138.6	—	57. 4
S S W 160 miles	—	147. 8	—	61. 3
S by W 130 miles	—	127. 5	—	25. 3
South 140 miles	—	140. 0	—	—
East 110 miles	—	—	110 0	—
690 miles	—	554 <sup>0</sup>	110. 0	144. 0
				110. 0
				34. 0

Therefore by this last reckoning backe againe *Ca. Codd* should be to the Northwards of the Summer Islands 554 miles, and to the Eastwards 34 miles, whereas by the former reckoning outwards, it was to the Northwards, onely 487 miles, and to the Westwards 30 miles, so that the difference of these two reckonings outwards and backe againe, is 67 miles Northerly, and 64 miles Easterly, which sheweth that the current in that time, namely in nine dayes, hath set to the Northwards 67 miles, and to the Eastwards 64 miles, that is, Northeast a little Northerly 93 miles, as by the foregoing table doth appeare, which is  $10\frac{2}{3}$  miles every day.

And what wee have here done by the tables, might have beene done (as the foregoing problemes) by the Doctrine of plaine Triangles.

**FINIS.**

